

REPORT DOCUMENTA

AD-A255 553

Approved
No. 0704 0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

Searching existing data sources, make or any other aspect of this report and Reports 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 5 June 1992		3. REPORT TYPE AND DATES COVERED Master's Thesis, 1 Aug 91-5 June 92	
4. TITLE AND SUBTITLE A Progressive Resistance Weight Training Program Designed to Improve the Armor Crewman's Strength				5. FUNDING NUMBERS	
6. AUTHOR(S) CPT Bradley W. May				8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Command and General Staff College Attn: ATZL-SWD-GD Ft. Leavenworth, KS 66027-6900				10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)				11. SUPPLEMENTARY NOTES	
DTIC SELECTE SEP 09 1992					
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.				12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The duties of a tank crewman are physically demanding. If a tank crewman is stronger, he will perform his job better, easier, quicker, and safer. Therefore, the focus of this thesis is the design of a weight training program to improve individual strength which will result in enhanced performance. While U.S. Army physical fitness manuals contain substantial information on weight training and principles of strength training, current doctrine does not address the specific needs of armor crewmen in the performance of their tasks. Because there is no standardized or sample weight training program, each soldier must design his own plan by selecting exercises from the manuals. The goal of my research is to bridge this gap by synthesizing this information into a prototype program.					
14. SUBJECT TERMS Weight Training, Strength Training, Armor Crewman Strength Related Tasks				15. NUMBER OF PAGES 156	
				16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT		

A PROGRESSIVE RESISTANCE WEIGHT TRAINING PROGRAM DESIGNED
TO IMPROVE THE ARMOR CREWMAN'S STRENGTH

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE

by

BRADLEY W. MAY, CPT, USA
B.B.A., Northeast Louisiana University, 1981

Fort Leavenworth, Kansas
1992

Approved for public release; distribution is unlimited.

92-24794



16684

92 0 0 8


MASTER OF MILITARY ART AND SCIENCE


THESIS APPROVAL PAGE

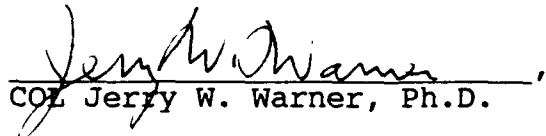
Name of candidate: CPT Bradley W. May

Title of thesis: A Progressive Resistance Weight Training
Program Designed to Improve the Armor Crewman's Strength

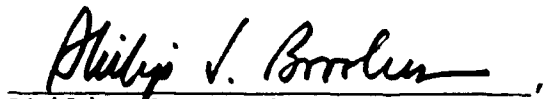
Approved by:

 , Thesis Committee Chairman
LTC Lee F. Kichen, M.A.

 , Member, Graduate Faculty
LTC David L. Wallinger, B.S.

 , Member, Consulting Faculty
COL Jerry W. Warner, Ph.D.

Accepted this 5th day of June 1992 by:

 , Director, Graduate Degree
Philip J. Brookes, Ph.D. Programs

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

A PROGRESSIVE RESISTANCE WEIGHT TRAINING PROGRAM DESIGNED TO IMPROVE THE ARMOR CREWMAN'S STRENGTH

by

CPT Bradley W. May, USA

156 pages

The duties of a tank crewman are physically demanding. If a tank crewman is stronger, he will perform his job better, easier, quicker, and safer. Therefore, the focus of this thesis is the design of a weight training program to improve individual strength which will result in enhanced performance.

While U.S. Army physical fitness manuals contain substantial information on weight training and principles of strength training, current doctrine does not address the specific needs of armor crewmen in the performance of their tasks. Because there is no standardized or sample weight training program, each soldier must design his own plan by selecting exercises from the manuals. The goal of my research is to bridge this gap by synthesizing this information into a prototype program.

iii

Accession For	
NTIS GSA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

DTIC QUALITY INSPECTED 1

ACKNOWLEDGEMENTS

This thesis is dedicated to my grandmother, Mrs. Maurine Davis, who passed away September 19, 1991.

A very special thanks to my committee and Ms. Carol Cole for their time, expertise, wisdom, and guidance.

To my parents, Lieutenant Colonel Bruce Burda, Lieutenant Colonel Gerald Cummins, Jr., Lieutenant Colonel Pat Blazek, Major Jane Maliszewski, Major Greg May, Major Paul Buhl, Major Gordan Thompson, Major Mike Turner, Major Pat Locke, Major George Knapp, Major Richard Zak, Major Tom McWhorter, Major Chip Bridge, Major Mason Thornal, Captain Tony Tata, Captain Art Degroat, Captain Sam Parris, Captain Kelly Morningstar, Captain Curt Hoover, Mrs. Nancy Guin, Ms. Carol Ramsey, Mr. Santo Ferrara, Mrs. Marsha Parris, Ms. Helen Davis, Mr. Craig McLean, Mr. John Rogers, Mr. Pete LaChance, Dr. Lewis Tomasi, Mr. Larry McNown and the rest of the officers of Staff Group 10B for their support and technical assistance.

To Bruce Algra for allowing me to use his exercise illustrations: "Bruce Algra Charts," 1984 series, Bakerfield, CA.

Also, to Human Kinetics Publishers for giving me permission to use the exercise narratives from "Free Weight Exercises" by J.A. Peterson in Strength Training by the Experts (pp. 107-141) by D.P. Riley, 1977. Champaign, IL: Leisure Press. Copyright 1977 by Leisure Press.

And most of all, a very special thanks to my wife, Jan, and son, Chad for their unrelenting support which enabled me to see this project to the end.

TABLE OF CONTENTS

APPROVAL PAGE.....	ii
ABSTRACT.....	iii
ACKNOWLEDGEMENTS.....	iv
TABLE OF CONTENTS.....	v
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
Chapter One - INTRODUCTION.....	1
Chapter Two - LITERATURE REVIEW.....	20
Chapter Three - ANALYSIS.....	65
Chapter Four - DISCUSSION.....	77
Chapter Five - CONCLUSION AND RECOMMENDATIONS.....	85
Appendix A - OVERALL BODY EXERCISES.....	91
Appendix B - LEG EXERCISES.....	93
Appendix C - CHEST EXERCISES.....	112
Appendix D - BACK EXERCISES.....	123
Appendix E - SHOULDER EXERCISES.....	130
Appendix F - TRAPEZIUS EXERCISES.....	135
Appendix G - TRICEP EXERCISES.....	139
Appendix H - BICEP EXERCISES.....	142
Appendix I - FOREARM EXERCISES.....	145
Appendix J - APPROVAL LETTER TO USE DIAGRAMS.....	148
BIBLIOGRAPHY.....	150
INITIAL DISTRIBUTION LIST.....	156

LIST OF TABLES

Table 1.....	4
Table 2.....	5
Table 3.....	11
Table 4.....	46
Table 5.....	49
Table 6.....	52
Table 7.....	54
Table 8.....	67
Table 9.....	76
Table 10.....	86
Table 11.....	89

LIST OF FIGURES

Figure 1.....	42
Figure 2.....	50
Figure 3.....	55
Figure 4.....	80
Figure 5.....	81
Figure 6.....	96
Figure 7.....	98
Figure 8.....	101
Figure 9.....	103
Figure 10.....	105
Figure 11.....	107
Figure 12.....	109
Figure 13.....	111
Figure 14.....	115
Figure 15.....	118
Figure 16.....	120
Figure 17.....	122
Figure 18.....	125
Figure 19.....	127
Figure 20.....	129
Figure 21.....	132
Figure 22.....	134
Figure 23.....	137
Figure 24.....	141

LIST OF FIGURES (continued)

Figure 25.....	144
Figure 26.....	147

CHAPTER I

INTRODUCTION

The Army's Physical Fitness Test requires a minimum level of overall physical fitness for every soldier; however, commanders and leaders must ensure their units physically train the way they expect to fight. Innovative, demanding fitness programs oriented to the physical challenges of combat are essential to any unit's physical training strategy.¹

The duties of a tank crewman are physically demanding. If a tank crewman is stronger, he will perform his job better, easier, quicker, and safer. Therefore, the focus of this thesis is the design of a weight training program to improve individual strength which will result in enhanced performance.

This chapter includes the introduction, statement of the problem, the significance of the study, assumptions, facts, limitations/delimitations, and definitions. The statement of the problem includes justification for the program considering strength related peacetime and wartime tasks performed by armor crewmen.

Chapter 2 consists of a review of the literature including Army physical fitness manuals, popular civilian

¹U.S. Army, Army Regulation 350-41, Army Forces Training, (Washington, 1986), 9:3-6b.

physical fitness books, physiology textbooks, articles, experiments, magazines, theses, and armor-related manuals. Chapter 3 is an analysis of the research presented in the literature. From this analysis, a proposed weight training program designed to increase strength will be developed. Since this study is a literature review, validation of the proposed program requires field testing.

Chapter 4 is a discussion of training specificity. Chapter 5 is conclusions and recommendations. The conclusion is a prototype weight training program to be validated by field testing.

The primary question addressed by this thesis is: What type of weight training program will best meet the armor crewman's need for increased strength?

Secondary questions include:

- (1) How many repetitions should be done per set?
- (2) How many sets should be done per exercise?
- (3) How many days per week should one workout?
- (4) How long should rest between sets last?
- (5) How much weight should be lifted during a set?
- (6) What method of application, i.e., free weights, Nautilus, or Universal equipment best supports the armor crewman's needs?

After answering these questions, the results will render a proposed strength development program that can be field tested and validated.

The strength of my methodology is that my conclusion is based on scientific evidence which has been derived from previously conducted experiments. The weakness is that some of the experiments are dated; however, the results of more recent experiments and studies support the findings of the earlier ones.

Statement of the Problem

Tank crewmen need upper and lower body strength in addition to endurance and cardiorespiratory fitness to execute job related tasks. My analysis of selected tank crewman tasks validates the requirement for designing a weight training program to increase strength. During tank gunnery or preparation for combat, tank crewmen must manually stow ammunition and the loader must load main gun rounds which weigh between 37-53 pounds each and are 33-40 inches in length (Tables 1 and 2).

TABLE 1**TANK MAIN GUN AMMUNITION
(SERVICE)**

TYPE	LENGTH (INCHES)	WEIGHT (POUNDS)
M105mm, M900 APFSDS-T	39.5	40.8
M105mm, M833 APFSDS-T	39	38
M105mm, M456A2 HEAT-T	40	49
M120mm, M829A1 APFSDS-T	38.7	46
M120mm, M829 APFSDS-T	37	41
M120mm, M830 HEAT-T	39	53

*Information provided by Gunnery Division, Weapons Department, Fort Knox, Kentucky

TABLE 2**TANK MAIN GUN AMMUNITION
(TRAINING)**

TYPE	LENGTH -INCHES	WEIGHT-POUNDS
M105mm, M724A1 TP-T	33	32
M105mm, M490A1 TP-T	39	42
M120mm, M865 TP-T	35	45
M120mm, M831 TP-T	39	53

*Information provided by Gunnery Division, Weapons Department, Fort Knox, Kentucky

The M1 Main Battle Tank, equipped with the 105mm main gun, holds fifty-five rounds; forty-four rounds in the turret stowage compartment, three rounds in the turret rack, and eight rounds in the hull stowage compartment. The M1A1 equipped with the 120mm main gun, holds forty rounds; thirty-four rounds in the turret stowage compartment and six rounds in the hull stowage compartment. In contrast, the M60 series with the 105mm main gun holds sixty-three rounds;

thirteen in turret ready rack, three in the turret floor ready rack, twenty-one rounds in the turret bustle rack, fifteen rounds in the left hull rack and eleven rounds in the right hull rack.

When stowing ammunition, a tank crewman grasps the round with one hand on the end of the base while the other hand is positioned over the nose of the projectile. Managing the weight of the round with hands spread the distance of about a yardstick compounds the challenge of lifting it. The crew sets up an assembly line to pass the rounds from the ground to the top of the tank; from the top of the tank to the inside the tank; and from the inside of the tank to the ready racks in the turret and hull where the ammunition is stowed.

To reinforce the need for strength, the crewmen must handle the ammunition with great care because even slight damage can affect the accuracy of a round. The 120mm equipped M1A1 carries fewer rounds; however, the rounds are larger and heavier. Consequently, stowing and loading fewer, heavier, rounds, appropriately supports the need for additional strength and places less emphasis on the need for endurance or cardiorespiratory training.

Crew strength is a critical factor in situations requiring the evacuation of injured crew members. If a crew man is killed, wounded or unconscious inside a burning tank, another crew member or members must lift him out of the tank

to evacuate him. Additional strength would enable the crewmen to perform this life-saving task more efficiently. If the wounded or unconscious crewman has a traumatic injury, extreme care must be taken not to cause further injury. This justifies the need for added strength.

Three strength related maintenance tasks routinely performed are: (1) checking the link assembly, (2) torsion bars, and (3) replacing a roadwheel. The tank crew member must use heavy tools and equipment to execute these tasks. Checking the link assembly requires a crewman to open the number one skirt on each side of the M1 series tank. The number one skirt on each side of the tank weighs 900 pounds. Numbers two, three, four, five, and six skirts weigh between 300-400 pounds. Two crewmen must lift the skirts using a basic issue crowbar and then swing them open until each locking arm reaches its limit. In addition, the skirts must be opened to check the suspension system, e.g., center guides, end connectors, and wedges on the tank. Checking torsion bars requires the crewman to pry the roadwheels up with a crowbar. Using upper and lower body strength, it takes 150 foot pounds of torque to apply enough force to the crowbar to insure that torsion bars are tested properly. When over 50 percent of the rubber is chunked or separated, a roadwheel must be replaced. Replacing a roadwheel is similar to replacing a flat tire on a car; however, a roadwheel weighs 60 pounds.

A former tank battalion commander who commanded in Korea, a former tank battalion executive officer who served in Germany, and a former tank company commander who served in Desert Shield/Storm support the premise that a weight training program is needed given the strength related tasks a tank crewman must perform. Each of these individuals indicated that although no formal program existed, most soldiers in their unit could have benefitted from one. The former battalion commander mentioned that additional strength is required to emplace and remove anti-tank mines, because each mine weighs approximately 30 pounds. Another consideration is the strength required to erect camouflage nets to enhance the concealment of the tank.

The former battalion executive officer observed a significant increase in confidence displayed by individuals who had started a weight training program on their own. It can be postulated that as a soldier gains strength, his confidence will grow in addition to his stamina. In fact, articles such as "Flexibility and Strength Training Considerations for Young Athletes," "Anthropometric Strength and Physiological Changes in Male and Female Swimmers with Progressive Resistance Training," and "Prevention of Sports Injuries in High School Students through Strength Training" cite self-esteem as a benefit of strength training.

The former company commander, who served in Desert Shield/Storm, indicated that his loaders participated in the

same physical training program as everyone else in his company. This program did not include weight training. To develop upper body strength, most of his soldiers relied on pushups. In special cases, if an individual appeared significantly weaker than his peers, he was sent to the gym to lift weights in an effort to improve his strength. Although these individuals made progress, a formal program would have helped considerably, one can assume.

Significance of the Study

This study is significant because a program to enhance muscular strength will help tank crewmen perform strength related tasks more efficiently. This in turn will contribute to an increased level of readiness for the unit. The program could also be considered for inclusion into a revision of FM 21-20, Physical Fitness Training or used to develop a standardized program for Armor units.

While Army physical fitness manuals contain substantial information on weight training and principles of strength training, current doctrine does not address the specific needs of armor crewmen in the performance of their tasks. Because there is no standardized weight training program, each soldier must design his own plan by selecting exercises from the manuals. The goal of my research is to

bridge this gap by synthesizing this information into a prototype program.

Assumptions

(1) Findings and conclusions of experiments reported in the literature reviewed are generally accepted by the academic community as accurate and valid.

(2) Given the strength requirements of certain tank crew tasks there is a need to develop a weight training program.

(3) Increased strength results in enhanced performance.

Facts

As tanks get larger, heavier, and more lethal, so do certain components or parts. Examples include main-gun rounds, firing pins, breechblocks, torsion bars, and skirts. A comparison of the weight of these components on the M1A1 and the M60 series, minus the main-gun rounds, is displayed at Table 3.

Even if future tanks include an automatic loader, the need for the strength program remains valid. The automatic loader would replace the fourth crewman and the three remaining tank crewmen must assume those tasks now performed by the loader.

TABLE 3

**COMPARISON OF WEIGHTS
OF TANK COMPONENT PARTS
(WEIGHTS EXPRESSED IN POUNDS)**

COMPONENT PART	M60A3	M1A1
BREECHBLOCK	88	200
COMMANDER'S HATCH	105	110
FIRING PIN	.04	15
TORSION BAR	102-104	400
SKIRT	NO SKIRTS	600-900

*Information provided by Abrams LOG, TACOM and AMC.

Limitations/Delimitations

The study focuses on strength development and is not a program that encompasses nutrition, endurance training, and cardiorespiratory training. The Army has a substantial body of information addressing each of these. The program is designed to enhance a tank crewman's ability to perform strength related tasks. It is not a program for body-building (physique development), powerlifting (bench press, squats, and dead lift), or weightlifting (clean and jerk, and snatch). This program is not designed to replace the Army Physical Fitness Test (APFT) but, to augment daily physical training regimens. The recommended program is developed from an analysis and comparison of the available literature describing previously developed programs. This study is limited to armor crewmen.

Definition of Terms

Physical Fitness Terms

- (1) Bi-set: Lifter conducts two consecutive exercises for the same body part with little or no rest in between sets. It is similar to the superset but instead of alternating body parts such as biceps and triceps, the lifter works only one body part at a time.
- (2) Cheating: Bouncing or jerking the weight in order to execute a repetition.
- (3) Concentric: The shortening of the muscle during the contraction. For example, curling a barbell.
- (4) Eccentric: The lengthening of the muscle as tension develops. For example, lowering a barbell after a concentric curl.
- (5) Forced Reps: Continuing a set after muscle failure. This is accomplished through the assistance of a training partner or "spotter."

(6) Giant sets: Working four or five sets of different exercises for the same body part.

(7) Heavy and Light Routine: Working several sets of an exercise using heavy weights and few repetitions followed by several sets of light weights and high repetitions. More than fifteen repetitions is considered high.

(8) Hypertrophy: The term used to describe the increase in size of mass of a cell, tissue, or organ. For example, increase in muscle fiber size resulting from strength training.

(9) Isokinetic: A muscle contraction at a constant speed with the muscle generating force against a variable resistance. For example, using a Cybex machine.

(10) Isometric: A muscle contraction with the muscle generating force that doesn't allow significant shortening of the muscle. For example, pushing against a wall.

(11) Isotonic: A muscle contraction with the muscle generating force against a constant resistance with a combination of shortening and lengthening of the muscle. Isotonic and progressive resistance weight training are synonymous for purposes of this study.

(12) Load: The amount of weight or poundage used for a particular set.

(13) Muscle Failure: Executing a set until no more repetitions can be performed.

(14) Muscle Fiber: A structural unit of muscle often called a muscle cell.

(15) Overload Principle: The physiological fact that a muscle subjected to greater-than-normal load will increase, over time, in size and strength.
(During the course of a program, the weight must be progressively increased to continue to get stronger).

(16) Peak Contraction: Finishing an exercise at its most difficult point.

(17) Progressive Resistance Weight Training: Weight training designed to strengthen specific muscles by causing them to overcome a fixed resistance, usually in the form of a barbell, dumbbell, or weight machine.

(18) Push-and-Pull Workouts: To work all pushing movements in one session (presses, tricep extension, and squats) and all pulling movements in another session (rowing, chins, and curls).

(19) Repetition Maximum (RM): The maximum weight a person can lift for a given number of repetitions.

(20) Repetitions (Reps): The number of consecutive contractions performed during each weight training exercise.

(21) Set: The number of repetitions performed for each exercise.

(22) Specificity: Exercises selected for a program should closely resemble the motion or movement required of the actual task one is trying to perform.

(23) Split Routine: Dividing exercises into two or three parts. For example, train the upper body in one work-out and the lower body in another work-out.

(24) Strength: A source of power or force. The ability to overcome resistance.

(25) The Stripping Method: At the conclusion of a set, a training partner lightens the load by removing or lowering some portion of the weight being lifted. Once the weight is reduced, the lifter continues to perform repetitions.

(26) Superset: Training two muscle groups consecutively. Alternating biceps and triceps would be an example of supersetting. More specifically, a lifter conducts a set of tricep extensions immediately following a set of bicep curls. Rest between supersets is encouraged, however, rest between sets is not recommended.

(27) Tri-set: Performing three consecutive exercises for the same body part or muscle group with minimal rest between sets. A tri-set for the chest could include a set of bench press, a set of incline dumbbell press, and a set of decline bench press.

(28) Underload: When the weight no longer provides the necessary resistance required to induce additional gains.

(29) Workload: The resistance a person must overcome.

Tank Component Terms

(1) Breechblock: Moveable steel block that closes the breech of a cannon.

(2) Center Guides: Steel brackets which keep the track aligned with road wheel.

(3) End Connectors: Steel attachments which connect trackblocks together to form the track.

(4) Hull: Lower portion of the tank which contains the engine, track, and driver.

(5) Link Assembly: Allows increase or decrease of track tension.

(6) Roadwheel: Wheels which maintain ground pressure and alignment of the track.

(7) Skirts: Heavily armored panels that provide protection to the upper portion of the track and suspension.

(8) Torsion Bar: A bar-shaped spring that is anchored on one end and operates by offering resistance as torque is applied at its other end.

(9) Turret: Portion of the tank which traverses 360 degrees and houses the tank commander, gunner, and loader and also contains the main-gun armament and ammunition.

(10) Wedges: Blocks designed to reinforce end connectors.

CHAPTER II

LITERATURE REVIEW

Weight training dates back to the ancient Olympic Games. The first known weightlifter was a Greek wrestler named Milo of Croton.¹ Milo would strengthen himself by lifting a small calf over the period of time that it took for the calf to grow heavier.² This is the first known recording of the overload principle.³

Weight training, as we know it today, began in Germany and other Middle European countries in the 1800s.⁴ Professional strongmen, travelling with carnivals and vaudeville acts, lifted barbells to impress the crowds with their physical prowess.⁵ Although these individuals were considered professionals, the majority of them started in amateur clubs or taverns where men met to challenge others to box, wrestle, or to lift weights.⁶ The weights lifted in those days could be characterized as bulky, clumsy, and non-

¹Jim Murray and Peter Karpovich, M.D., Weight Training in Athletics, (New Jersey: Prentice-Hall Inc., 1956), 3.

²Daniel P. Riley, Strength Training by the Experts, (New York: Leisure Press, 1977), 97.

³Ibid.

⁴Murray and Karpovich, 5.

⁵Ibid.

⁶Ibid.

interchangeable.⁷ It was not until 1900 that weight training gained considerable recognition in the United States.

In the United States, the first individual to bring weight training to the attention of the public was Alan Calvert.⁸ He started the Milo Barbell Company in 1903 and sold a course on weight training and strength development that could still be followed today.⁹ Initially, his barbells consisted of empty spheres at the ends of the bar which could be made heavier by pouring lead into the spheres.¹⁰ Later, he replaced the spheres with weighted plates similar to those used today.¹¹

Calvert published a magazine entitled Strength and a book called Super Strength which were considered the day's best sources.¹² Eventually, Calvert decided to release the reigns of the Milo Barbell Company and Strength magazine to Mark Berry.¹³ In 1934, the Milo Barbell Company was purchased by Bob Hoffman, who founded the York Barbell Company in 1932.¹⁴

Hoffman was interested in all sports but developed a special interest in weight training. He experienced both size and strength gains from weight training that he could

⁷Ibid.

⁸Ibid., 13.

⁹Ibid.

¹⁰Ibid.

¹¹Ibid.

¹²Ibid.

¹³Ibid.

¹⁴Ibid.

not gain from any other athletic activity.¹⁵ Through his weight training endeavors, he also improved his performance in other sports such as canoeing, rowing, and track and field.¹⁶ After founding the York Barbell Company, Hoffman began publishing Strength and Health magazine in which he commended the values of weight training as an exercise and sport.¹⁷ Since then, many publications have been written on the subject. Following is a summary of sources used to design the weight training program in this thesis.

U.S. Army Physical Fitness Manuals

Field Manual 21-20, Physical Fitness Training, Washington, DC, 1985, is the Army's doctrinal manual for conducting physical fitness training. With respect to strength development, it addresses principles of strength training, isotonic, eccentric, isometric, and isokinetic contractions. It also describes repetitions, sets, frequency of training, recommended degrees of weight to be lifted, and methods and techniques for lifting weights. However, no sample strength development program is provided.

The manual describes how to train if equipment is not available. For example, when a unit is in the field. This technique is known as partner-resisted training where a

¹⁵Ibid., 14.

¹⁶Ibid.

¹⁷Ibid.

soldier uses the resistance of another soldier to work a particular muscle. Photographs of soldiers executing these exercises are included in chapter three.

Department of the Army Pamphlet 350-18, The Individual's Handbook on Physical Fitness, Washington, DC, 1983, does not include a weight training program, but does provide information which would assist the soldier in developing his own program. The program should include flexibility, warm-up, and cardiorespiratory exercises followed by a cool down period, flexibility exercises, muscular strength training, and finally more flexibility exercises. In this particular pamphlet the recommended time spent on muscular strength training is 10-15 minutes.

Army Regulation 350-15, The Army Physical Fitness Program, Washington, DC, 1989, issues responsibilities and provides training guidance, objectives, and philosophy of the Army Physical Fitness Program. This regulation applies to both Active and Reserve components. The mechanics of a weight training program are not addressed.

U.S. Army Pamphlet 350-15, The Commander's Handbook On Physical Fitness, Washington, DC, 1982, provides commanders with the information to design a fitness program that will meet the Army's fitness goals to enhance

health, good appearance, pride, discipline, and combat readiness. The handbook focuses on total fitness with specific emphasis on aerobic training. Included is an excellent individual aerobic program focusing on running and improving APFT scores. However, there is no sample strength training program.

Physical Fitness Books

The U.S. Army Total Fitness Program, published in 1985, was written by LTC Robert Hales, M.D. and Mrs. Diane Hales. LTC Hales, M.D., is a graduate of the United States Military Academy at West Point and George Washington University Medical School. Mrs. Hales has written several books on fitness that focus on health, pregnancy, and sleep. Only a small portion of this book is dedicated to muscular fitness since the focus is on total fitness.

Chapter two concentrates on flexibility and stretching. The Army has learned, as a result of numerous injuries, the importance of stretching. Today, warm-ups and stretching are an integral part of most formal physical fitness programs. The authors provide excellent guidance for safe stretching, including continuous breathing throughout and not pushing your muscles beyond the normal range of motion. They recommend raising your body temperature prior to rigorous exercise by slowly running in

place. Cold muscles, joints, and tendons are more susceptible to injury if not properly warmed-up.

Chapter four examines muscular fitness and strength training. The authors clearly conclude that training with weights is a sound method for building strength. With respect to training principles, one must exercise differently for strength than for endurance. Few repetitions with heavy weights develop strength while more repetitions with lighter weights develop endurance.

The authors provide the following guidelines for soldiers to follow while lifting weights:

- (1) A lifter should train with a partner for safety and motivation. The partner can serve as a "spotter" to provide necessary assistance so that the weight doesn't overpower or fall on the lifter. The partner can also motivate a lifter by providing verbal moral support.

- (2) Warm-up with light weights before increasing the load and level of intensity to allow the body to cope with the new stress and to reduce muscle soreness.

- (3) Train larger muscles first and allow a minimum of 48 hours between training a body part so that the muscle can adequately recover.

- (4) Inhale when lifting a weight and exhale when releasing it.

- (5) Use proper form to avoid serious injury.

Tom Kubistant's Mind Pump, published in 1988, concentrates on the importance of using your mind to get the most out of your workouts. Specifically, he discusses methods for improving concentration, staying motivated, relaxing, and focusing on the workout. The foundation of the psychology of weight training is concentration. Numerous lifters will go to great extremes to avoid concentration because it requires effort. Unfortunately, in doing so, maximum benefits of the workout are lost. Focusing on each set, repetition, and correct form unite the body and mind for better gains.

Each chapter is replete with self-assessments, examples, and guidelines to assist in assimilation of the material. Concluding each chapter is a summary which can be applied to a workout. One method for tracking the progress of a workout is keeping a log. Instructions on how to keep a log are provided. Moreover, using the sample logs in the book is highly recommended. Tracking the progress helps foster commitment.

The New Hardcore Bodybuilding, published in 1990, is a best seller written by Robert Kennedy. He discusses training strategies and formulas for gaining body mass. Kennedy acquired his information from successful bodybuilders who have been able to make significant muscular size and strength improvements.

Chapter 1 discusses the role genetics plays in building muscle and strength while chapters 2 through 6 deal with warming up, workout frequency, sets, repetitions, correct form, beginner's game plan, nutrition and supplements. Chapters 7 through 14 give guidance on how to train each body part. Chapter 15 is devoted to principles and techniques including forced repetitions, supersets, bi-sets, tri-sets, cheating, peak contraction, giant sets, the stripping method, heavy and light routines. According to the author, one advantage of the cheating technique is that it shocks the body into growth. One disadvantage is that the lifter is vulnerable to injury because he is usually training with weight beyond his RM.

Raw Muscle, published in 1989, is the sequel to another best selling weight training book entitled MASS. Dennis B. Weis is the author and Robert Kennedy provided the photos. This book is not intended for the novice lifter but rather those already familiar with the basics. Chapter 5 concentrates on intermediate and advanced training programs as well as recovery. The data in this chapter is detailed and comprehensive, but it is unclear what conclusive or specific studies the programs are based on. The book contains additional information on muscle recovery, exercise, nutrition, and special training tips which appear to have merit, according to professional bodybuilders.

In order to maximize size and strength gains, beginner and intermediate lifters should avoid training techniques such as supersets, giant sets, and the stripping method because there is little or no rest between sets. Since there is no or minimal rest between sets, the muscle does not sufficiently recover to handle the necessary load to create adequate hypertrophy. These techniques should be used by the advanced lifter who is not training for additional strength or size.

The Nautilus Bodybuilding Book, published in 1982, was written by Dr. Ellington Darden, Director of Research for Nautilus Sports/Medical Industries. Dr. Darden discusses training programs, Nautilus workouts, and push-and-pull workouts, all of which contribute to muscular gains in both size and strength. With respect to strength, Dr. Darden asserts that the size of the muscle positively correlates with strength.

The book begins with a discussion about Arthur Jones, the inventor and developer of Nautilus exercise machines. Jones' asserts that:

- (1) Muscles grow when they are stimulated.
- (2) Growth stems from a stimulated muscle that has had time to recover from the previous workout.

(3) Muscles must be stimulated at regular intervals. Therefore, muscular growth is dependent upon both rest and work.

There is a common misconception in weight training that more is better. Because the demands of a high-intensity workout are clearly great and necessary to stimulate growth, it is not uncommon for lifters to overtrain. It is normal to be tired after a workout. However, twenty minutes after a workout, one should begin to feel as though he could complete the workout again although this should not be attempted. If an individual is consistently tired, he has probably not fully recovered from the previous workout. Increasing the recovery time and making sure nutritional needs are met may be the answer. The challenge is finding the right balance. A muscle that undergoes a low-intensity workout also will not grow because it is undertrained.

The author discusses goals and techniques for gaining strength. He states that it is impossible for most individuals to develop the massive physiques seen in muscle magazines because of genetics. However, gaining muscular strength, developing a positive self-image, improving heart and lung capacity, and becoming more adept in a sport are clearly attainable goals for anyone.

Conducting warm-up exercises is essential to reducing the chance for injury and to allow the muscles to perform

more efficiently during the workout. Proper form when performing an exercise is also essential. This includes isolating the muscle being worked, relaxing muscles not being worked, proper speed and range of movement throughout the set, and making sure there is a "spotter" or training partner for assistance or supervision.

To build strength, the author asserts that repetitions must be performed in a strict manner to produce optimal gains. Cheating or using adjacent muscle groups when performing repetitions during a set increases the chance for injury and reduces the probability for maximum growth of the involved muscle. The involved muscle is the focus of a particular exercise. Performing repetitions at a slower pace as opposed to a faster pace is more productive according to ten years of research conducted at the Nautilus Sports/Medical Industries. Six seconds appears to be an effective guideline for time spent on a repetition; two seconds to raise the weight and four seconds to lower it. Additionally, repetitions performed at a faster pace can increase the chance for injury to the joints and ligaments. Training with a partner is a good safety feature because training to a level of high-intensity often requires help to perform the final repetitions. The training partner also supplies the necessary motivation to lift the heavy weight. The author also describes each machine and how to use it effectively.

Franco Columbo's Complete Book of Bodybuilding

published in 1982, provides a basic program for the beginning lifter as well as advanced techniques for the professional bodybuilder. Dr. Columbo holds a Ph.D. in nutrition and has won the Mr. Olympia title, the most prestigious title in bodybuilding. The book begins with an introduction which includes warm-up exercises, conditioning exercises, beginning resistance exercises, and weight training exercises.

The program suggests how often to train, when to train, what to do if a workout is missed, and information about various types of weight training equipment. The application of anatomy to training, the importance of training with a partner, and the effect of motivation and attitude on a workout are also included.

With respect to training programs he provides beginner, intermediate, and advanced level routines. In each of these, he articulates the body part to be exercised, the number of repetitions and sets to be completed, and which days of the week the body parts should be worked. Prevention of injuries, importance of nutrition, and training strategies are considered as well as training techniques that can be used to improve performance in all type of sports.

Physical Fitness A Way of Life, published in 1983, is an easy reading book written by Dr. Bud Getchell. He translates scientific terminology and scholarly documentation into easily understood language. The book is a result of many years of research. He concludes that weight training programs incorporating barbells and dumbbells are the most efficient means for gaining strength. In order to develop strength, a muscle must be overloaded. Routine daily living does not provide the necessary stimulation to generate muscular growth.

A synopsis of the book's main points is:

- (1) Isotonic programs increase strength better than isometric programs.
- (2) Strength is best gained by methodically stressing the muscles beyond the normal load.
- (3) The amount of strength gained is a direct result of the extent of overload.
- (4) Training three times per week using weight training equipment will result in significant strength gains in six to eight weeks.
- (5) Weight training programs which do not incorporate cardiorespiratory training are not sufficient enough to maintain healthy levels of lung, heart, and blood vessel fitness.
- (6) Isokinetic programs represent a relatively new concept in strength development. During an isokinetic

movement, the amount of resistance created by the machine is always equal to the amount of force being applied. Unless the training facility is equipped with this expensive equipment, training with isokinetic machines is impossible.

One of the most common ailments is low back pain which is largely the result of abdominal muscle and spinal region weakness. The author recommends various exercises to remedy this particular problem. Gains in strength can occur from weight training programs which incorporate two RM for one set to ten RM for three sets. Dr. Getchell cites Dr. Richard Berger, a well-known muscular fitness researcher, who claims that ideal strength gains occur using six RM for three sets, three times per week. Dr. Getchell also recommends that a training journal be kept to accurately record progress and help regulate the workout.

The book graphically depicts various exercises and describes their purpose, correct starting position, movement throughout the exercise, and recommended amount of weight to use. Dr. Getchell concludes with a reminder to make sure cardiorespiratory training is combined with strength training so that the lungs, heart and blood vessels receive adequate conditioning.

Physiology Books

Exercise Physiology: Energy, Nutrition, and Human Performance, 3rd edition, published in 1991, was written by William D. McArdle, Frank I. Katch, and Victor L. Katch. Chapter 22 of this textbook focuses on measuring and improving muscular strength. Equipment used to train muscles is divided into three categories. The first category includes barbells and free weights where speed and resistance is governed by the individual. The second category is split into two divisions:

(1) Devices which provide a controlled speed and variable resistance.

(2) Hydraulic machines which provide constant speed and variable resistance with the individual controlling the speed. The third category includes cam devices where speed is variable and resistance is constant. Regardless of the type of equipment used, the key to gaining strength is the intensity of the overload of the muscle. Any of the categories of equipment previously discussed can be used to create overload.

A summary of the optimal number of repetitions, sets, frequency, and workout intensity is provided. For increasing strength, findings show between three and nine repetitions is best for executing one set. Performing three sets of an exercise increases strength more than one set.

Training one to five days a week increases strength in beginners, however, performing multiple exercises in the same workout two to three times a week produces greater gains in strength for beginners. During a set, repetitions done at a faster rate of movement appear to build strength better than a slower rate. An additional assertion is that free weights and machines both build strength with neither being superior to the other.

For beginners, a load between 60 to 80 percent of 1 RM capacity will generate growth in strength. During the first two to three weeks of training, maximum lifts should be avoided to minimize injury. It is best to start with a weight that can be lifted for 12 to 15 repetitions. Selecting the right amount of weight is a trial and error process. Increase the amount of weight so that no more than 15 repetitions can be performed. After two to three weeks, the muscles should begin to adapt. Consequently, the number of repetitions should be reduced to 6 to 8. When more than eight repetitions can be performed with a specific weight, increase the amount of weight accordingly.

To prevent injuries, the lifter must use proper form. Improper training with heavy weights can put enormous strain on the lower spine. Additional repetitions will not result in additional strength if done incorrectly. Training with a weightlifting belt which supports the abdominal region and lower back can help reduce the chance for injury. A belt

should be used when lifting near maximum weights and while performing exercises which significantly involve the lower back. Squats and dead lift are prime examples of exercises in which the lifter should wear a belt. Some training without the belt is recommended for the development and strengthening of abdominal muscles. Maximum lifts should not be done without a belt.

Three major systems for developing strength are progressive resistance weight training, isometric strength training, and isokinetic resistance training. Muscular hypertrophy, genetics' role in gaining strength, and muscle soreness are discussed. The information is thorough and supported by experiments or conclusive studies.

The Physiological Basis of Physical Education and Athletics, 2nd edition, published in 1976, was co-authored by Donald K. Mathews and Edward L. Fox. Nancy Allison Close did the illustrations. Chapter seven discusses advantages and disadvantages of isometric, isotonic, eccentric, and isokinetic weight training programs. It defines terms, and seems to do an excellent job of comparing overload and underload principles.

To increase performance, a specific program must be planned which focuses on the tasks that the individual must perform. Gains in muscular strength will occur when a progressive resistance program is used to simulate the

movement of the tasks which an individual desires to improve. Fast-twitch or white muscle fibers are designed for spring-like activities whereas slow-twitch or red muscle fibers are more for endurance. Consequently, in order to optimize performance, one must design his program based on increasing the capabilities of the desired types of muscle fibers.

Trying to conclude which type of program is best is a difficult task. There is no simple answer. In chapter seven of this book, a study concluded that an isokinetic program produced greater strength results than did an isometric or isotonic program. The subjects were college males who trained three times a week for twelve weeks.

When designing an effective strength gaining program one must consider the overload principle, the specificity of the program, and the type of equipment available to use. Chapter seven also includes a review of the research completed on strength development which concluded that progressive weight training programs containing strenuous resistance exercises produce superior strength results.

Sports Physiology, published in 1979, was written by Edward L. Fox, Professor and Director, Laboratory of Work Physiology, The Ohio State University, Columbus, Ohio. Nancy Allison Close served as the illustrator.

Chapter six of this publication attempts to resolve any confusion surrounding the premise that weight resistance training is a myth. The author accomplishes this by presenting four basic principles which form the foundation for any weight training program.

The four principles include overload, progressive resistance, specificity, and the arrangement of the program.

(1) Overload stimulates strength gains. What is considered overload in the beginning of a program becomes underload when the weight no longer provides the necessary resistance required to induce additional gains. During the course of a program, the weight must be progressively increased to achieve the desired results.

(2) Progressive resistance describes the methodology used to organize a program. Larger muscles should be worked before smaller ones. Additionally, as the lifter gets stronger, he should increase the weight in order to continue to grow.

(3) Specificity exercises means that exercises selected for a program should closely resemble the motion or movement required of the actual task one is trying to perform.

Chapter six includes an excellent summary of the advantages and disadvantages of the three types of resistance programs. According to the author, the isokinetic program was superior to the isotonic and

isometric programs for gaining strength. The isotonic program produced greater strength gains than the isometric program. To compare of theses programs, the criteria selected included:

- (1) rate of strength gained
- (2) rate of endurance gained
- (3) strength gained over range of motion
- (4) time per training session
- (5) expense
- (6) ease of performance
- (7) ease of progress assessment
- (8) least possibility of muscle soreness
- (9) least possibility of injury
- (10) skill improvement

The chapter also includes studies comparing:

- (1) numbers of sets
- (2) numbers of repetitions
- (3) frequency or many days per week to workout
- (4) duration of training

Examples of training programs and recommended exercises are graphically depicted for easy understanding.

A discrepancy in terminology exists in the exercise or sports physiology textbooks. This discrepancy extends to the number or types of programs or systems and the number of types of contractions contained therein.

In Exercise Physiology: Energy, Nutrition, and Human Performance, 3rd edition, McArdle, Katch, and Katch, describe three types of contractions (concentric, eccentric, and isometric) which are used as a basis for three exercise systems (progressive resistance weight training, isometric training, and isokinetic training). On the other hand, in Sports Physiology, Fox outlines four types of programs (isotonic, isometric, eccentric, and isokinetic) which are based on three types of contractions (isotonic, isometric, and isokinetic). Furthermore, in The Physiological Basis of Physical Education and Athletics, Mathews and Fox describe four types of programs (isotonic, isometric, eccentric, and isokinetic) which rely on four types of contractions (isotonic, isometric, eccentric, and isokinetic).

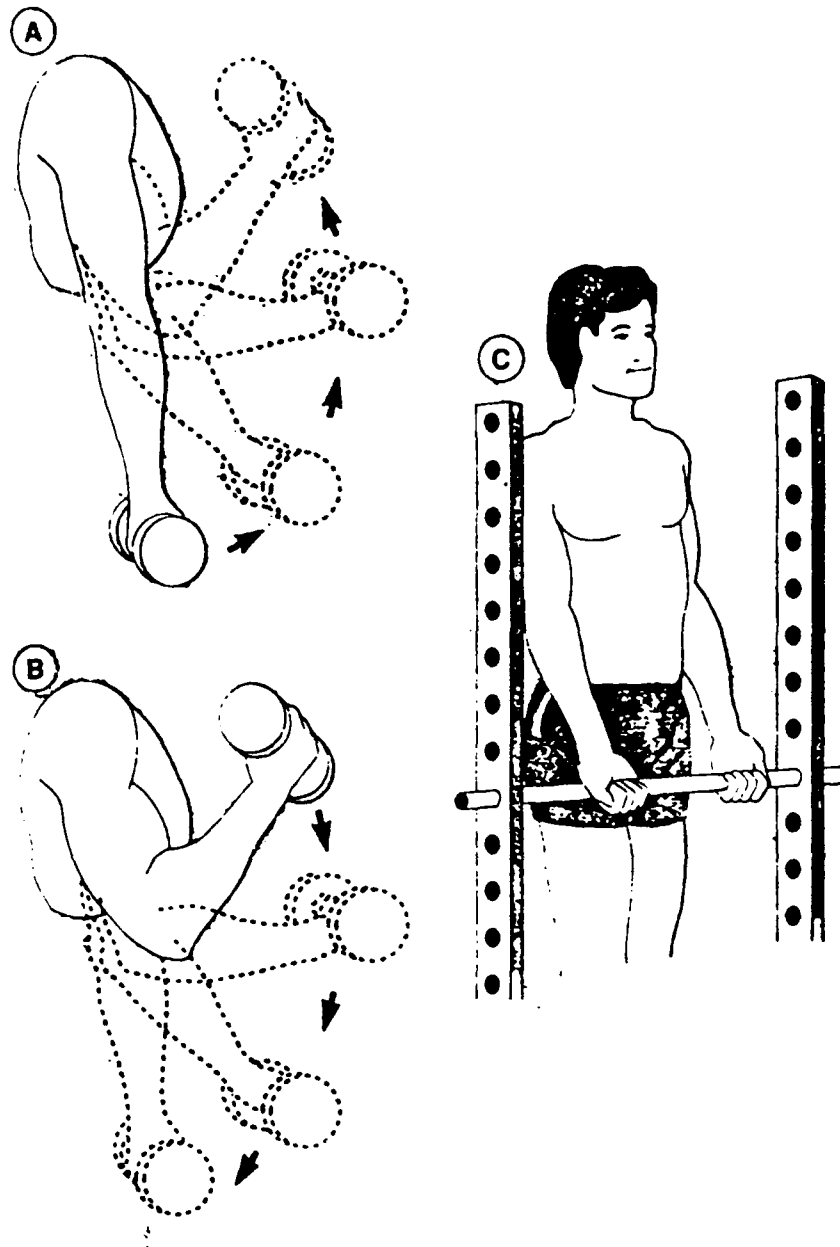
The controversial terms are isotonic, concentric, and eccentric. Sports Physiology and The Physiological Basis of Physical Education and Athletics, describe a program using free weights as isotonic. According to Exercise Physiology: Energy, Nutrition, and Human Performance, which is the most current reference of the three described in this paragraph, "...the combination of concentric and eccentric contractions is frequently, but imprecisely been termed isotonic exercise."¹⁸ This term is inexact because isotonic implies constant tension. During a repetition using free weights

¹⁸William D. McArdle, Frank I. Katch, and Victor L. Katch, Exercise Physiology: Energy, Nutrition, and Human Performance, 3rd ed. (Pennsylvania: Lea and Febiger, 1991), 461.

the load is constant but the force applied is not constant since acceleration and deceleration is required through the execution of the movement.¹⁹

The term isotonic and progressive resistance weight training are synonymous for purposes of this study even though progressive resistance weight training is a more accurate term. Concentric and eccentric describe the action that takes place during the execution of a repetition. For example, during a bicep curl using a dumbbell, when the weight is raised, the muscle is concentrically contracted. As the weight is lowered, the muscle is eccentrically contracted (Figure 1).

¹⁹Ibid.



**FIGURE 1. ILLUSTRATION OF (A. ECCENTRIC),
(B. CONCENTRIC) AND (C. ISOMETRIC) CONTRACTIONS**

Progressive resistance weight training (isotonic) and isokinetic weight training are considered dynamic because each involve skeletal movement. During dynamic activity, muscles contract concentrically and eccentrically. Isometric training is considered static because force is generated against the muscle fibers to induce contraction, but there is no movement of the skeleton.

Isotonic exercises primarily involve the lifting of standard plates or weights which include both barbells and dumbbells, Universal plates, and some types of Nautilus. Testing of strength gains using isotonic means date back to the 1940's when DeLorme and Watkins developed and examined a program used initially for rehabilitation purposes and later for athletic purposes.²⁰ Although it is clear that strength can be gained using isotonic exercises, optimal gains depend on the number of repetitions and sets performed as long as the overload is achieved. For that matter, this applies to any type of exercise system.

Isometric exercises involve contracting the muscle by applying force against an immovable object. The pioneers of this type of system were Hettinger and Muller, two German scientist, who claimed strength gains could be made by contracting the muscle for six seconds at two-thirds maximal

²⁰Edward L. Fox, Sports Physiology, (Pennsylvania: W.B. Saunders Company, 1979), 127.

intensity once a day for five days per week.²¹ Follow-on studies were conducted to support this exciting and revolutionary concept; however, results proved inconclusive.

Isokinetic exercises are still a relatively new concept but already have produced excellent strength gains. Two problems associated with this system is isokinetic devices are not readily available due to high costs and strength gains depend entirely on the effort of intensity applied by the individual since the bar on the isokinetic machine can be moved with minimal effort.

Nautilus had the opportunity to incorporate isokinetics into their machines but decided not to because it produces an inferior restricted speed resistance.²² Training with isokinetics does not actually produce resistance. On the contrary, it only takes a small amount of effort to move the resistance bar. The bar will move only at a predetermined speed even if the lifter pushes or pulls hard or easy.²³ The theory behind isokinetics is that the resistance remains constant throughout the range of movement.²⁴ When one applies maximum effort throughout the movement, the resistance will always be right. The lifter sets the speed, but once set, one is limited to this speed.²⁵

²¹Ibid., 144.

²²Ellington Darden, Ph.D., The Nautilus Bodybuilding Book, (Chicago: Contemporary Books, Inc., 1982), 167.

²³Ibid.

²⁴Ibid., 166.

²⁵Ibid.

Even though the makers of isokinetic machines see this as an advantage, Nautilus sees it as a disadvantage because there is no resistance at the end of the movement thus all of the muscular structure being worked can not be involved.²⁶ Also, since only minimum effort is needed to move the bar, the lifter might be tempted not to put forth his maximum effort. For these reasons, Nautilus Sports/Medical Industries has determined isokinetics to be an inefficient way to gain maximum muscular strength and size.²⁷

When comparing these types of systems; however, a study found in Sports Physiology, concluded that the isokinetic program in which the exercises were performed at fast speed movements produced the optimum strength gains.²⁸ Table 4 provides a synopsis of the study comparing the three types programs.

²⁶Ibid.

²⁷Ibid., 167.

²⁸Fox, 144.

TABLE 4

**SYNOPSIS OF COMPARISON OF
ISOTONIC, ISOMETRIC, AND ISOKINETIC
WEIGHT TRAINING
PROGRAMS**

	RATING			
CRITERION	<i>ISOTONIC</i>	<i>ISOMETRIC</i>	<i>ISOKINETIC</i>	
RATE OF STRENGTH GAINED	2	1	3	
RATE OF ENDURANCE GAINED	2	1	3	
STRENGTH GAINED OVER RANGE OF MOTION	2	1	3	
EXPENSE OF EQUIPMENT	2	3	1	
EASE OF PERFORMANCE	1	3	2	
ADAPTIBILITY TO SPECIFIC MOVEMENT PATTERNS	2	1	3	
EASE OF ASSESSMENT	3	1	2	
MUSCLE SORENESS	1	2	3	
POSSIBILITY OF INJURY	1	2	3	
<i>TOTAL</i>	<hr/> 16	<hr/> 15	<hr/> 23	

*for ratings assigned, higher number is better.

SYNOPSIS DERIVED FROM INFORMATION FROM SPORTS PHYSIOLOGY,
FOX, 1979.

Other studies conducted by Stone and O'Bryant and Atha concluded that the isokinetic system was not superior to other systems of exercise for improving strength. Additionally, an advantage of exercising with free weights is the individual is required to lift the weight off of a rack then balance it. As the weight is lowered and raised, the muscles contract throughout the movement of a repetition. This closely replicates executing strength related tasks required of the armor crewman on a daily basis.

Since they are so controversial, more studies need to be conducted on isokinetic exercise programs. One must consider equipment availability to design a solid program. Since isokinetic equipment is not readily available and progressive resistance weight training (isotonic) appears to be superior to isometric training for gaining strength, a progressive resistance weight training (isotonic) system seems to be the most logical choice for inclusion in the proposed program.

Experiments/Articles/Magazines/Thesis

Richard A. Berger, Texas Tech University in Lubbock, Texas, conducted a study entitled "Optimum Repetitions for the Development of Strength," which was published in The Research Quarterly, in 1961. The objective of the study

was to determine the optimum number of repetitions to result in the most significant increases in strength improvement.

One hundred ninety nine male college students at the University of Illinois were tested before and after 12 weeks of progressive resistance exercise. The students were divided into six classes each performing a different number of repetitions per set. Using the bench press lift, resistances for each class were 2 RM, 4 RM, 6 RM, 8 RM, 10 RM, and 12 RM respectively for one set.

To determine significant differences in the gains in strength, covariance was analyzed. Table 5 depicts the comparisons between the groups. The coefficient of reliability for strength on the bench press was determined to be .97 indicating a high degree of confidence. This was determined using the test-retest method on college students who were not part of this experiment.

The results of the post-test for each group, are presented in Figure 2. An analysis shows that groups trained with high resistance and low repetitions experienced greater strength gains. Results demonstrated that groups trained with 4, 6, and 8 repetitions produced larger average gains than the groups trained with 2, 10, and 12 repetitions. Therefore, according to Berger, the optimum number of repetitions was found to be between three and nine.

TABLE 5

**ANALYSIS OF COVARIANCE BETWEEN SIX
DIFFERENT TRAINING PROGRAMS**

SOURCE OF VARIATION	df	SUM X²	SUM XY	2 Y²	
BETWEEN	5	8,005	4,679	3,749	
WITHIN	193	96,787	95,222	117,050	
TOTAL	198	104,792	99,901	120,799	
		SUM OF SQUARES	df	MEAN	
		ERRORS OF ESTI-	df	SQUARE	F
		MATE			
TOTAL		25,561	197		
WITHIN		23,368	192	121.71	3.603^a
BETWEEN		2,193	5	438.60	

^a significant beyond the .01 level

*INFORMATION EXTRACTED FROM BERGER, 1961

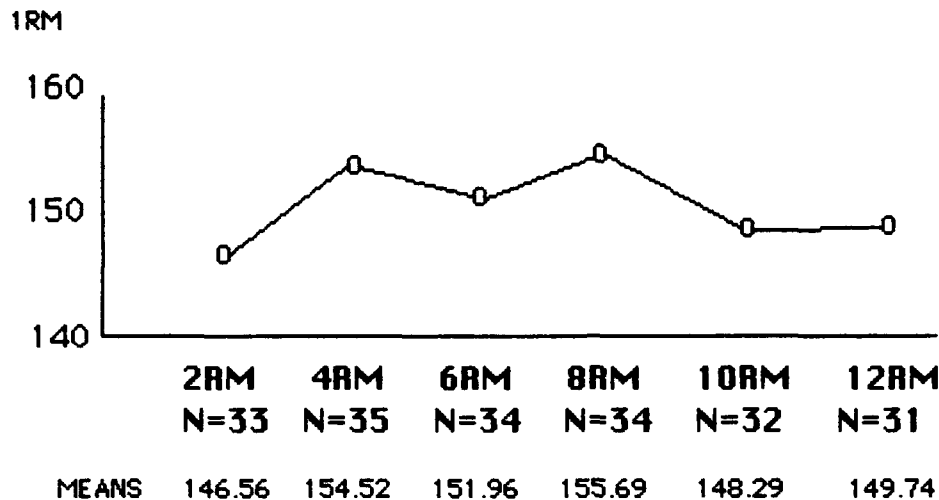


FIGURE 2. MEAN STRENGTH OF SIX WEIGHT TRAINING PROGRAMS
FROM BERGER, 1961.

The study's finding that 3 to 9 repetitions produced greater improvement in strength is supported by the same conclusion found in Exercise Physiology: Energy, Nutrition, and Human Performance written by William D. McArdle, Frank I. Katch, and Victor L. Katch. Based on these conclusions, three to nine repetitions appear to be a sound target if performing one set per exercise.

Richard A. Berger conducted another study which was published in 1962 entitled "Comparative Effects of Three Weight Training Programs." A total of 48 college students, divided into three groups, performed various resistance programs to determine whether fewer sets, lighter loads, and more repetitions produced greater strength results than frequent sets, heavy loads, and few repetitions. Each group

trained three times per week for nine weeks using the bench press lift. One group performed 2 RM for six sets while another group performed 6 RM for three sets. A third group trained with 10 RM for three sets per session. The 1 RM for each individual was determined during pre- and post-testing.

To determine whether there was a significant difference in strength gains between the groups at the end of the nine weeks, an analysis of covariance was used. The analysis at Table 6 showed that there was no significant difference between the means. When the study was continued for twelve weeks, the group that performed 6 RM for three sets achieved a significantly higher mean than the other groups. According to Berger, further research should be performed to determine the optimum combination of sets and repetitions.

TABLE 6

**ANALYSIS OF COVARIANCE BETWEEN THREE
DIFFERENT WEIGHT TRAINING PROGRAMS
AT NINE WEEKS OF TRAINING**

SOURCE OF VARIATION	SUM H^2	SUM HY	SUM Y^2	df
TOTAL	21,789	21,931	25,762	47
W/IN GROUPS	21,646	21921	25,675	45
	<hr/>	<hr/>	<hr/>	<hr/>
BETWEEN GROUPS	152	10	87	2
SOURCE OF VARIATION	SUM OF SQUARES OF ERRORS OF ESTIMATE	df	MEAN SQUARE	F
TOTAL	3,698	46		
W/IN GROUPS	3,568	44	81.09	
	<hr/>	<hr/>		
ADJUSTED BETWEEN GROUPS	130	2	65.00	.80^a

a Not significant

*INFORMATION EXTRACTED FROM BERGER, 1962

"Effects of Three Resistance Training Programs on Muscular Strength and Absolute and Relative Endurance" is a study conducted by Tim Anderson and Jay T. Kearney of the University of Kentucky, appearing in Research Quarterly for Exercise and Sport, in 1982. The objective of the study was to assess the effects of three resistance training programs on muscular strength and on absolute and relative muscular endurance. Forty-three male college students, divided into three groups, trained three times per week for nine weeks using the bench press exercise. The high resistance-low repetition group (n = 15) executed three sets of 6-8 RM per session while the medium resistance-medium repetition subjects (n = 16) performed two sets of 30-40 RM per session. The low resistance-high repetition group (n = 12) performed one set of 100-150 RM.

Tests of strength (1 RM), absolute and relative endurance were given before and after nine weeks of training. According to the statistical analysis, the high resistance-low repetition group achieved a 20 percent improvement in maximum strength while the medium resistance-medium repetition and low resistance-high repetition groups experienced 8 percent and 5 percent gains, respectively (Table 7). These findings support the observations of DeLorme (1945), who proposed that high resistance-low repetition exercises build strength and low resistance-high repetition exercises produce endurance (Figure 3).

TABLE 7**DESCRIPTIVE STATISTICS
FOR MAXIMUM STRENGTH**

TRAINING REGIMEN	MAXIMUM STRENGTH		
	PRE	POST	% CHANGE
HIGH RESISTANCE- LOW REPETITION	67.73 =4.30	81.43 =5.04	20.22
MEDIUM RESISTANCE- MEDIUM REPETITION	65.96 =5.18	71.38 =4.06	8.22
LOW RESISTANCE- HIGH REPETITION	65.44 =5.03	68.66 =4.91	4.92

*Values reported as means and standard deviations. Statistics reflect kilograms lifted. Information from Anderson and Kearney, 1982.

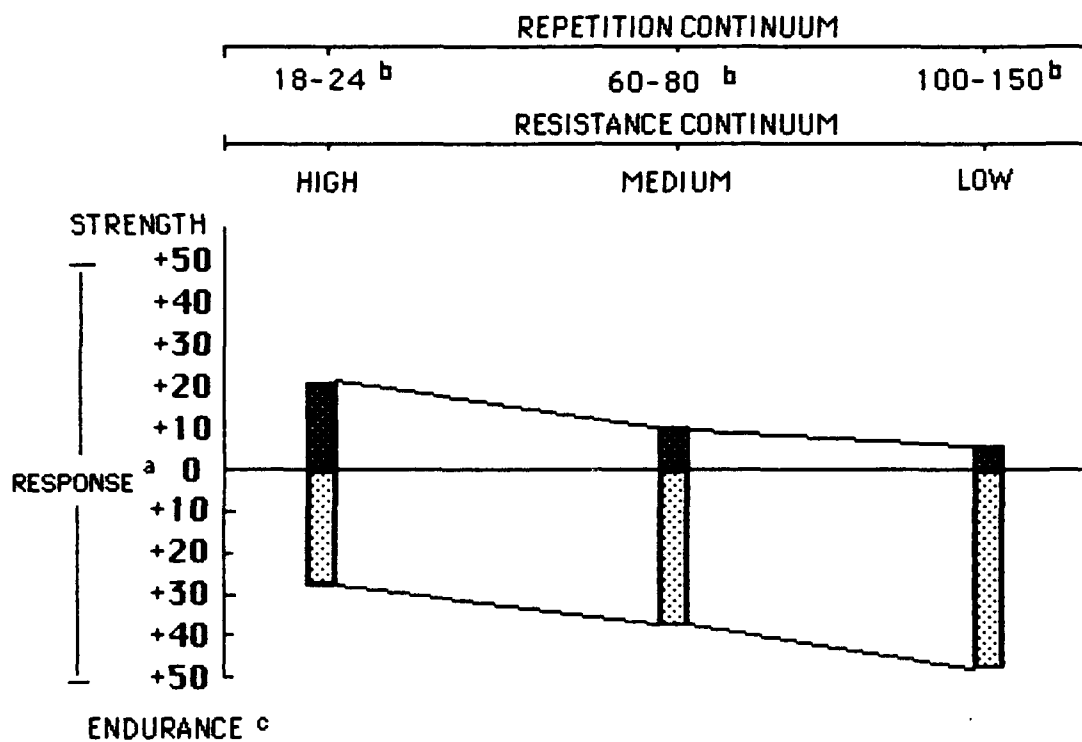


FIGURE 3. RESPONSES OF MAXIMUM STRENGTH AND ENDURANCE AS A FUNCTION OF POSITION ON THE RESISTANCE-REPETITION CONTINUUMS. INFORMATION FROM ANDERSON AND KEARNEY, 1982

- ^a Expressed in percent change
- ^b Repetitions per training session
- ^c Absolute endurance

"Muscle Strength and Power Changes during Maximal Isokinetic Training," by George R. Lesmes, David L. Costill, Edward F. Coyle, and William J. Fink was published in Medicine and Science in Sports, Volume 10, Number 4, in 1978. The purpose of the study was to determine the impact of high-intensity, short term training on muscles using an isokinetic dynamometer. A dynamometer, an instrument used to measure strength, tested and exercised the extensors and flexors of the knee. The subjects trained four times per week for a period of seven weeks using repeated knee extensions and flexions.

The subjects trained four times per week for a period of seven weeks using repeated knee extensions and flexions. They trained at maximal force and constant velocity with one leg repeating six second repetitions and the other leg repeating thirty second repetitions.

Results indicated:

(1) Isokinetic training programs of six and thirty seconds in length can dramatically boost peak muscular torque.

(2) A significant consideration for improving peak torque may be training velocity.

(3) Total work output could be raised an average of 30% with either training velocity.

(4) A reduction in the fatigue of the knee extensor muscles was observed in both training programs.

"Effects of Varied Weight Training Programs on Strength," by Richard Berger, was published in The Research Quarterly, Volume 33, Number 2, in 1961. This article reports the results of a twelve week program to determine which type of nine weight training programs was more effective in improving strength. The programs involved variations of one, two or three sets of bench press lifts with two, six or ten repetitions per set. Twenty subjects participated in the test three times each week. Each subject was tested for one RM at the beginning of training, and after every third week. The results indicated that six repetitions per set for three sets was optimal for gaining strength.

"Comparison between Resistance Load and Strength Improvement," by Richard Berger, was published in The Research Quarterly, Volume 33, Number 4, in 1962. The purpose of this study was to determine whether a submaximum load using progressive resistance training was as effective in improving strength as a maximum load. Numerous studies, using repetitions at maximum effort, have been conducted to determine which type of program is best for improving strength. Muller, Rarick and Taylor conducted one such experiment using isometric training. Their conclusions

indicate that training with two thirds of the maximum effort is as effective as training with the maximum effort.

In the Berger experiment, twenty-eight students were tested for 1 RM on the bench press lift before and after twelve weeks of training. During this twelve week training period, thirteen subjects trained three times weekly with 90 percent of 10 RM. Each group trained with 90 percent of the 10 RM plus the 10 RM had adjusted means of 151.18 pounds respectively after a total of 12 weeks of training. Both groups had mean strength gains that were highly significant ($P = .01$). Because the groups were not equal, an analysis of covariance was used which showed that no significant difference existed between the groups. For increasing strength, training with submaximal loads of 90 percent proved just as effective as training with maximum loads with 10 RM. Berger concludes that training with submaximal loads is just as effective for improving strength as training with maximum loads.

He suggests additional experiments should be conducted to determine the minimum percentage of 10 RM that will produce the same growth in strength as training with the 10 RM.

"Comparison of the Effect of Various Weight Training Loads on Strength," by Richard Berger, was published in The Research Quarterly, Volume 36, Number 2, in 1964.

This study was undertaken to determine what, if any, amount of maximum strength would be as effective for increasing strength as training with 1 RM.

Seventy-nine male subjects, were divided into three groups. The groups trained twice weekly with 66, 80, or 90 percent of 1 RM and once weekly with 1 RM. A fourth group trained with 1 RM three times per week; a fifth group trained with 66 percent of 1 RM; a sixth group trained with 1 RM only once a week and a seventh group was the control group.

After six weeks of training, the control group and the group that trained three times per week with two-thirds of 1 RM had mean strength scores which were substantially lower than the means of the other groups.

"Comparison of Strength Development of Adult Males and Females undergoing Dynamic Weight Training," is a thesis by J.L. Campos of the University of Iowa in 1980. Forty-four students participated in an experiment comparing strength gains of males and females who enrolled in a weight training program for seven weeks. The students were divided into a male group ($n = 20$) and a female group ($n = 24$). To be accepted into the experiment, subjects could not be participating in any weight training program or rigorous exercises on a frequent basis. In addition, a subject could

not be participating in any organized sports immediately before the beginning of the study.

For a period of seven weeks, each subject performed three sets of 6 RM three times per week using the bench press lift. The test of maximum dynamic strength used in this study consisted of 1 RM before and after the study concluded. To analyze statistical significance between the initial and final strength scores for each group, a matched pairs t-test was used. An analysis of covariance was employed to determine the significance of the difference between the two groups.

The matched pairs t-test revealed that both groups achieved exceptional gains in strength after seven weeks of training using three sets of 6 RM. The female group made a 36.8 percent gain in strength while the male group gained 27.5 percent.

"Sets and Repetitions," by Bruno Pauletto published in NSCA Journal in 1985 begins with the definition of various strength related terms such as repetitions, sets, and RM. The author states that programs be scientifically based. A person designing a program should understand the principles of program design, the specific type of conditioning required to support the sport for which one is training and the response of the trainees to the training program. For gaining muscular strength, a muscle must be

overloaded to induce maximal contraction. According to research reviewed by the author, there is no single combination of repetitions and sets to create optimal gains. However, most researchers conclude that the optimal number of repetitions is between three and nine. In addition, it is generally accepted that using heavy weights for low repetitions results in the greatest strength gains in the shortest period of time.

When a weight training program is begun, one can expect rapid gain during the first few weeks even if the program is not properly designed. However, once the gain slows, a program must be tailored to meet the needs of the individual.

Armor Crewman related Manuals

Soldier Training Publication 17-19K1-SM,
Soldier's Manual M1/M1A1 Abrams Armor Crewman, published in 1989, includes tasks, requiring significant strength, which the armor crewman must perform as part of his job. In addition, conditions and standards are included for evaluation purposes.

Technical Manual 9-2350-255-10-3, Volumes 1 and 3,
Operators Manual Troubleshooting and Maintenance for Tank,
Combat, Full-Track 105-mm Gun, M1, General Abrams, dated

1981, is the operator's manual for troubleshooting and maintenance. This manual outlines the strength related maintenance tasks which the armor crewmen must perform.

Soldier Training Publication 21-1-SMCT, Soldier's Manual of Common Tasks Skill Level 1, dated 1990, provides commanders and soldiers with standardized training objectives for tasks which are common to all skill level 1 soldiers. The conditions and standards for strength related tasks to evacuate a wounded or dead soldier are prescribed in this manual. It is used in all units to sustain training.

Tank Combat Tables, M1, FM 17-12-1 with Change 1,2,and 3, published in 1986 (Change 3 in 1990), focuses on a systematic approach to training armor crewmen for combat using gunnery and tactical tables. It specifies how the tank crew and tank platoon train to attain weapon systems proficiency through the conduct of these tables. It also provides methods to engage and destroy targets efficiently as part of training for combat.

The tables provide tasks, conditions, and standards which are based on detailed analysis of actual hit and kill probabilities of US tanks versus threat tank or anti-tank weapons. Of particular interest is the Tank Crew Gunnery Skills Test (TCGST) which involves the training and testing

gunnery-related tasks, specifically the loading of main gun rounds.

Station 8A on page C-4 of the manual includes:

Task: Load the 120mm main gun. (Rounds weigh between 37-53 pounds)

Conditions: Given a stationary M1A1 tank with main gun breech open, a 120mm dummy round in the ready ammunition rack with the ammunition door closed, and a fire command; all crew stations have been prepared for operation.

Standards: The crewman will load the main gun within seven seconds after the ammunition element of the fire command is announced.

Station 8 is concerned with loading the 105mm main gun. The standard for loading the 105mm main gun round is five seconds rather than seven. If the loader does not possess the requisite strength to perform these tasks to standard, the crew may not survive on the modern battlefield.

Summary of Literature Review

Each reference provided excellent information to help develop the program. Physical fitness books furnished pertinent information on how to perform exercises as well as training strategies to enhance strength gains. Although the purpose of this study is not to design a physique development program, various bodybuilding references supplied valuable information for gaining strength. Exercise physiology texts and experiments on gaining strength provide the nucleus of information on which this program is founded. U.S. Army and Armor Crewmen manuals outline strength related tasks which must be executed to specific standards for combat survival. Combat survival is predicated on the effective performance of strength related tasks. Therefore, a training program which increases the strength of the armor soldier is essential for battlefield success.

CHAPTER III

ANALYSIS

This chapter will answer the secondary questions which include:

- (1) How many repetitions should be done per set?
- (2) How many sets should be done per exercise?
- (3) How many days per week should one workout?
- (4) How long should rest between sets last?
- (5) How much weight should be lifted during per set?
- (6) What method of application, i.e., free weights, Nautilus, or Universal equipment best supports the armor crewman's needs?

To answer these questions and derive the contents of my program, I analyzed experiments, exercise physiology texts, and data found in the physical fitness books discussed in the literature review. This analysis helped me derive the appropriate information for determining maximum strength gains.

The variables compared are: repetitions per set, sets per exercise, frequency, rest between sets, loads or

how much weight should be lifted. Table 8 provides a synopsis of the comparison of these variables.

Table 8 presents the results of a literature review of eight references addressing one or more of the secondary questions.

TABLE 8

**COMPARISON OF STRENGTH RELATED VARIABLES
WHICH COMPRISE A WEIGHT TRAINING PROGRAM**

REFERENCES	SECONDARY QUESTIONS				
	REPS/ SET?	SETS/ EXERCISE?	FREQ DAYS/ WEEK	REST B/ SETS?	LOAD?
<u>SPORTS PHYSIOLOGY</u> , FOX, 1979	6	3	3	5-10	--
<u>EXERCISE PHYSIOLOGY: ENERGY, NUTRITION, & HUMAN PERFORMANCE</u> , McARDLE, KATCH, & KATCH, 1991	3-9	3	2-3	--	--
"EFFECTS OF THREE RESISTANCE TRAINING PROGRAMS ON MUS- CULAR STRENGTH AND RELATIVE ENDURANCE," ANDERSON AND KEARNY, 1982	6-8	3	3	--	6-8 RM
"DESIGNING RESISTANCE TRAINING PROGRAMS," FLECK & KRAEMER, 87	6	3-6	--	--	6 RM
"RESISTANCE TNG," FLECK & KRAEMER, 88	6	3-6	3	2-3 MIN	6 RM
"SETS & REPS," PAULETTO, 85	3-9	--	--	--	--
"EXERCISE PRE- SCRIPTION" KRAEMER, 1985	--	3-6	48 HRS BETW/ WKOUTS	3-4 MIN	--
"EFFECTS OF VARIED WEIGHT TRAINING PROGRAMS ON STRENGTH," BERGER, 1961	6	3	--	--	--

Repetitions per Set

Seven of eight references address a recommended number of repetitions per set:

- * Four references recommend six repetitions.
- * Two references recommend three to nine repetitions.
- * One reference recommends six to eight repetitions.

The recommended number of repetitions by reference is arrayed below:

REFERENCES	REPETITIONS
McArdle, Katch, & Katch, 91	3, 4, 5, 6, 7, 8, 9
Fleck & Kraemer, 88	6
Fleck & Kraemer, 87	6
Pauletto, 85	3, 4, 5, 6, 7, 8, 9
Anderson & Kearney, 82	6, 7, 8
Fox, 79	6
Berger, 61	6

To examine the results, choose a reference in the left column and read directly across to find the author's recommended number of repetitions. Where more than one

number appears on a row, the author asserts that the optimum number of repetitions is somewhere between the first and last number. After glancing at all the columns on the right, six repetitions stands out because the number 6 appears most frequently (mode).

Six repetitions per set are logically included in the proposed program because six is the mode.

Sets Per Exercise

Seven of eight references recommend an optimum number of sets per exercise:

- * Four references recommend three sets.
- * Three references recommend three to six sets.

The recommended number of sets by reference is arrayed below:

REFERENCES	SETS
McArdle, Katch, & Katch, 91	3
Fleck & Kraemer, 88	3, 4, 5, 6
Fleck & Kraemer, 87	3, 4, 5, 6
Kraemer, 85	3, 4, 5, 6
Anderson & Kearney, 82	3
Fox, 79	3
Berger, 61	3

To analyze the outcome, pick a reference in the left column and read directly across to find the author's recommended number of sets. Where more than one number appears on a row, the author claims that the optimum number of sets is somewhere between the first and last number. After scanning the columns on the right, three sets stands out because the number 3 appears most frequently (mode).

Three sets per exercise are included in the proposed program because three is the mode.

Workout Frequency

Five of eight references address workout frequency or the recommended number of days per week one should train:

- * Four references recommend three days per week with a minimum of forty eight hours rest between workouts.
- * One reference recommends two to three days per week with a minimum of forty eight hours rest between workouts.

The recommended workout frequency by reference is arrayed below:

REFERENCES	FREQUENCY (DAYS PER WEEK)
McArdle, Katch,& Katch, 91	2-3
Fleck & Kraemer, 88	3
Kraemer, 85	3
Anderson & Kearney, 82	3
Fox, 79	3

To understand the results, select a reference in the left column and read directly across to find the author's recommended workout frequency. Where more than one number appears on a row, the author states that the optimum workout frequency is somewhere between the first and last number. After reviewing the columns on the right, three days per week stand out because the number 3 appears most frequently (mode).

A workout frequency of three days per week with a minimum of forty eight hours rest between workouts is included in the proposed program because 3 is the mode.

Rest Between Sets

Three of eight references address rest periods between sets which allow adequate recovery to properly execute the next set.

- * One reference recommends two to three minutes rest.
- * One reference recommends three to four minutes rest.
- * One reference recommends five to ten minutes rest.

The recommended amount of rest between sets by reference is arrayed below:

REFERENCES	REST BETWEEN SETS (MINUTES)
Fleck & Kraemer, 88	2, 3
Kraemer, 85	3, 4
Fox, 79	5, 6, 7, 8, 9, 10

To examine the results, choose a reference in the left column and read directly across to find the author's recommended amount of rest between sets. The author asserts that the optimum amount of rest between sets is somewhere between the first and last number on a row. After glancing at all the columns on the right, no number clearly stands out so using a range may be more appropriate.

Five to ten minutes is not consistent with the other recommended rest periods, and will not be considered further. Since other references recommend a range including a rest period of two to four minutes, it will be included in the program. Perhaps a younger crewman may require only a two minutes rest, whereas an older crewman may rest four minutes between sets.

Load

Three of eight references address load or amount of weight lifted during a set.

- * Two references recommend 6 RM.
- * One reference recommends 6 to 8 RM.

The recommended load by reference is arrayed below:

REFERENCES	LOAD (by RM)
Fleck & Kraemer, 88	6
Fleck & Kraemer, 87	6
Anderson & Kearney, 82	6, 7, 8

To examine the results, choose a reference in the left column and read directly across to find the author's recommended RM load. Where more than one number appears on a row, the author asserts that the optimum load is somewhere

between the first and last number. After glancing at all the columns on the right, six RM stands out because the number 6 appears most frequently (mode).

Six RM per set is logically included in the proposed program because 6 is the mode.

Method of Application

As mentioned earlier, strength can be gained using various methods of application, i.e., free weights, Nautilus, and Universal equipment as long as overload is incorporated into the program. However, from a practical standpoint, a program using free weights appears to better support the armor crewman's needs. Table 9 shows a comparison of free weights, Nautilus, and Universal equipment. Selected criteria include replication of tasks (specificity), transportability, safety, and cost.

Free weights more closely replicate the tasks an armor crewman must perform daily as part of his job. Having to balance the weight throughout the execution of the exercise resembles the same requirement found in executing armor crewmen related tasks. For example, the crewmen must lift, while balancing, a defective roadwheel when it needs replacing. Furthermore, the new roadwheel must be lifted, to include balanced, to replace the defective one.

Free weights are certainly more transportable, which is a significant consideration given deployment and field training requirements. The weights can easily be placed in the bustle rack, possibly a sponson box, or even on the unit's supply truck.

Since both Nautilus and Universal equipment do not require the individual to lift the weight off of a rack and balance it, they would be considered safer than free weights. When lifting with free weights, especially for exercises which could pin the lifter between the weight and an exercise bench, a spotter should always be used for safety.

Another important factor supporting the use of free weights over Nautilus and Universal equipment is cost. Free weights are considerably cheaper to purchase.

TABLE 9

**COMPARISON OF METHODS
OF APPLICATION
(FREE WEIGHTS, NAUTILUS, UNIVERSAL)**

	RATING			
CRITERION	FREE WEIGHTS	NAUTILUS	UNIVERSAL	
REPLICATION OF TASKS	3	1.5	1.5	
TRANSPORTABILITY	3	1	2	
EXPENSE OF EQUIPMENT	3	1	2	
POSSIBILITY OF INJURY	1	2.5	2.5	
	—	—	—	
TOTAL	10	6	8	

*For ratings assigned, higher is better.

CHAPTER IV

DISCUSSION

A weight training program must consider the principle of specificity which matches the biomechanical movement involved in performing the strength related tasks. When loading a main gun round, a tank crewman primarily uses the biceps brachi, brachialis, brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis, pectoralis majors, deltoids (anterior and posterior), and triceps brachii. The lower body is not activated since the tank crewman is sitting while loading the round.

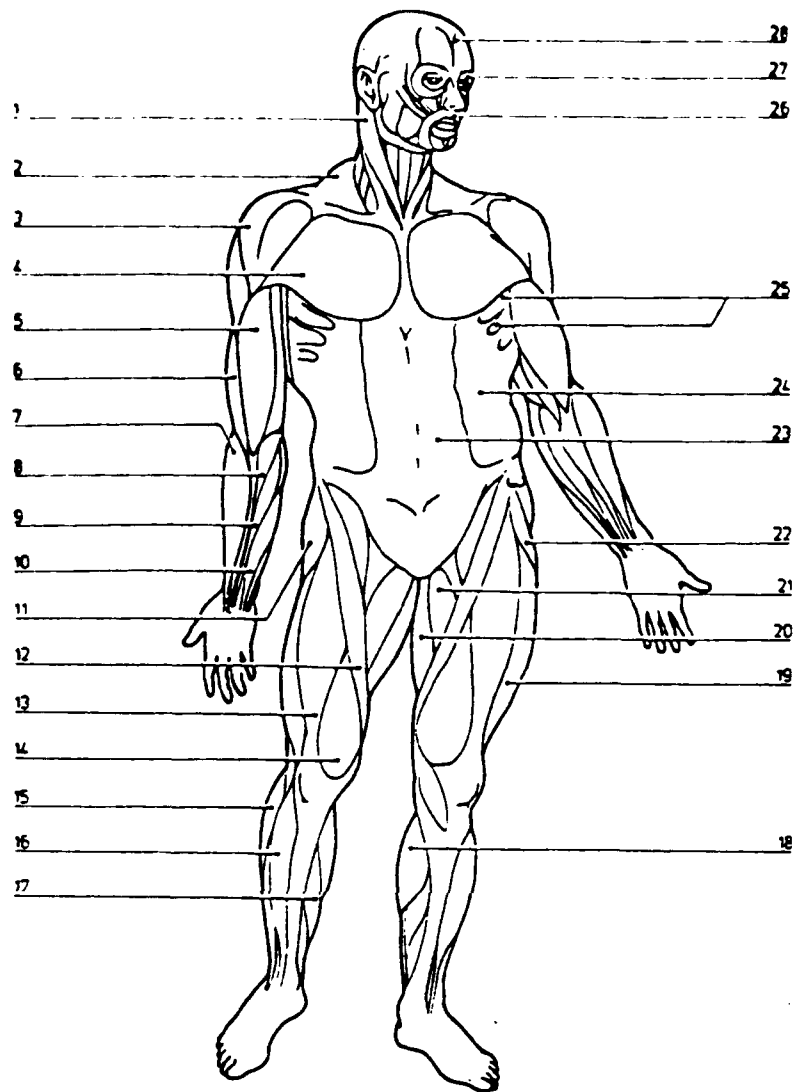
To stow ammunition, a tank crewman use his rectus femoris, vastus medialis, vastus lateralis, biceps femoris, semitendinosus, gracilis, soleus, and gastrocnemius, latissimus dorsi, and trapezius to initially pick up a main gun round. Then the deltoids (anterior and posterior), biceps brachi, brachialis, triceps brachii, and brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis are used to pass the round to another crewman standing on top of the tank. The same muscles are used to pass the round from outside to inside the tank where it is stowed. Figures 4 and 5 are

illustrations of the major muscles used to perform these tasks.

Using a crowbar to check for a broken torsion bar, requires a crewman to use his entire body. The crewman initially uses his rectus femoris, vastus medialis, vastus lateralis, biceps femoris, semitendinosus, gracilis, soleus, and gastrocnemius, latissimus dorsi, trapezius, biceps brachi, brachialis, and brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis as the crowbar is lifted. Once the crowbar is raised to chest level, the crewman then uses his pectoralis majors, deltoids (anterior and posterior) and triceps brachii to complete the check.

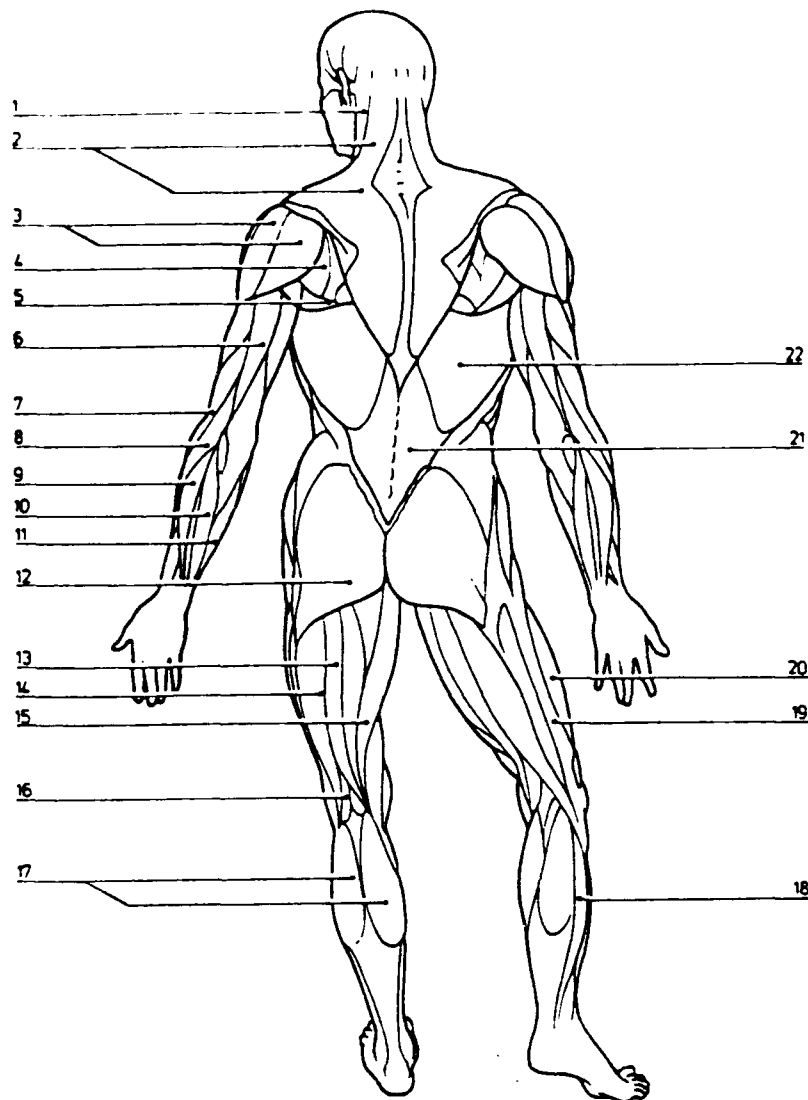
Although a chain hoist is used to raise and lower the breechblock from the main tube, a crewman must manually lift the breechblock from the turret floor to the outside of the tank if it needs to be replaced. The muscles involved to execute this task are the rectus femoris, vastus medialis, vastus lateralis, biceps femoris, semitendinosus, gracilis, soleus, and gastrocnemius, latissimus dorsi, trapezius, biceps brachi, brachialis, brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis, pectoralis majors, deltoids (anterior and posterior), triceps brachii. As the crewman lifts the breechblock, his legs should be bent at a 90 degree angle from the rest of the body. As he rises, the movement would be similar to the

dead lift and squats. The upper body remains erect while the latissimus dorsi, trapezius, biceps brachi, brachialis and brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis lift the breechblock to chest level. Bent-over-rows for the latissimus dorsi, upright rows for the trapezius, and bicep curls for the biceps brachi and brachialis are the exercises which closely match the movement of the involved muscles. The deltoids (anterior and posterior), pectoralis majors, and triceps brachii come into play as the breechblock is lifted over the head. The military press for the deltoid (anterior and posterior) replicates the action of lifting the breechblock over the head. An excellent exercise to build the pectoralis majors is the bench press while triceps extension serves as a superb exercise to build the triceps brachii.



Anterior view of superficial muscles	9	Palmaris longus	19	Vastus lateralis	
	10	Flexor digitorum superficialis	20	Gracilis	
1	Sternocleidomastoid	11	Gluteus medius	21	Adductor longus
2	Trapezius	12	Sartorius	22	Tensor fasciae latae
3	Deltoid	13	Rectus femoris	23	Rectus abdominis
4	Pectoralis major	14	Vastus medialis	24	External oblique
5	Biceps brachii	15	Peroneus longus	25	Serratus anterior
6	Brachialis	16	Tibialis anterior	26	Orbicularis oris
7	Brachioradialis	17	Soleus	27	Orbicularis oculi
8	Flexor carpi radialis	18	Gastrocnemius	28	Occipitofrontalis

FIGURE 4. MUSCLES OF THE HUMAN BODY, ANTERIOR VIEW.
(DIAGRAM FROM "BODY ON FILE")



Posterior view of superficial muscles		9	Extensor digitorum	20	Vastus lateralis
		10	Extensor digiti minimi	21	Thoracolumbar fascia
		11	Extensor carpi ulnaris	22	Latissimus dorsi
1	Sternocleidomastoid	12	Gluteus maximus		
2	Trapezius	13	Biceps femoris		
3	Deltoid	14	Semitendinosus		
4	Infraspinatus	15	Gracilis		
5	Teres major	16	Semimembranosus		
6	Triceps brachii	17	Gastrocnemius		
7	Brachioradialis	18	Soleus		
8	Extensor carpi radialis	19	Fascia lata		

FIGURE 5. MUSCLES OF THE HUMAN BODY, POSTERIOR VIEW.
(DIAGRAM FROM "BODY ON FILE")

Since replacing a roadwheel is similar to changing a flat tire on a car, the same muscles are used to perform this task. Lifting the roadwheel primarily involves the rectus femoris, vastus medialis, vastus lateralis, biceps femoris, semitendinosus, gracilis, soleus, and gastrocnemius, deltoid (anterior and posterior), latissimus dorsi, biceps brachi, brachialis and brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis. Exercises which closely match the execution of this task are the dead lift, squats, bicep and wrist curls. The military or overhead press is designed to strengthen the deltoids (anterior and posterior) which play a critical role in lifting the roadwheel.

When a sprocket needs replacing, upper body strength will be needed. The pectoralis majors, deltoids (anterior and posterior), biceps brachi, brachialis, brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis, and triceps brachii must rise to the occasion in order to complete the mission. Since the sprocket weights approximately 100 pounds, this job becomes at least a two man task. As the crewmen push the sprocket from their chest area to place it on the hub, a motion similar to a bench press is executed. The deltoids (anterior and posterior), triceps brachii, biceps brachi, brachialis, and brachioradialis, flexor carpi radialis, palmaris longus,

flexor digitorum superficialis play a secondary role since they are indirectly affected as the task is performed. Once again, overhead press, triceps extension, and bicep and wrist curls are functional exercises to prepare the body to be able execute this task. Before the sprocket is placed on the tank, it must be lifted to chest level. The muscles designed to fulfill this task are the rectus femoris, vastus medialis, vastus lateralis, biceps femoris, semitendinosus, gracilis, soleus, and gastrocnemius, latissimus dorsi, trapezius, biceps brachii, brachialis, and brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis. Exercises which enhance these muscles and most closely relate to the task at hand are the dead lift, squats, bent-over-rows, upright rows, bicep and wrist curls.

On the battlefield during an artillery attack, the tank commander may be required to raise and lower the hatch on the commander's cupola. Opening the hatch which weighs 80 pounds requires the tank commander to lift it using a motion similar to an overhead press. Not only are the deltoids stressed during this activity but also the triceps brachii, trapezius, pectoralis majors, latissimus dorsi, and brachioradialis, flexor carpi radialis, palmaris longus, flexor digitorum superficialis. The movement of the triceps brachii is similar to the action that takes place during a repetition of a triceps extension. The trapezius, pectoralis major, latissimus dorsi, and brachioradialis,

flexor carpi radialis, palmaris longus, flexor digitorum superficialis perform a secondary role; therefore, if strengthened they enable the tank commander to execute this task more efficiently and with greater ease.

Evacuating a casualty, especially one whom has a mobility injury, requires overall body strength. The amount of strength the individual possesses very well could make the difference as to whether or not the casualty sustains further injury. If the individual is injured inside the tank, a crewman or crewmen would be required to lift him out of the tank. Since the dead lift builds overall body strength, it would be an excellent exercise for developing the necessary strength to perform this task. Additionally, the action of lifting the casualty is comparable to the movement of the dead lift exercise.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

Conclusion

The exercises which I have selected are those which closely match the biomechanical movement of the tank crewman as he performs daily strength related tasks. Not only do the exercises closely match the movement, but they are designed to strengthen those muscles that must execute the tasks.

Given the number of tasks a crewman must perform, all major muscles in the body are used at some time. Therefore, the exercises selected are designed to improve the strength level of all the major muscles in the body. Additionally, the program is arranged so that the larger muscles should be worked before smaller muscles because smaller muscles become exhausted easier.

Table 10 shows the results of the analysis and the thesis conclusion, a progressive resistance weight training program designed to improve the armor crewman's strength.

TABLE 10

**A PROGRESSIVE RESISTANCE WEIGHT TRAINING
PROGRAM DESIGNED TO IMPROVE THE ARMOR
CREWMAN'S STRENGTH**

Body part-Muscles	Exercises	Sets	X	Reps
Legs				
Quadriceps-Rectus Femoris, and Hamstrings-Biceps Femoris	Squats	3	X	6
Chest -Pectoralis majors	Bench press	3	X	6
Back-Latissimus dorsi	Bent-over-rows	3	X	6
Shoulders-Deltoids	Overhead Press	3	X	6
Arms				
Triceps	Triceps Extensions	3	X	6
Biceps	Bicep Curls	3	X	6

The above program requires approximately 1.5 hours to perform. If not constrained by time, the lifter should add the exercises on the next page.

TABLE 10 (CONTINUED)

Body part-Muscles	Exercises	Sets	X	Reps
Overall body (perform before leg exercises)	Dead lift	3	X	6
Calves-Gastrocnemius (perform after upper leg and before chest exercises)	Toe-Raises	3	X	6
Trapezius (perform after shoulder and before tricep exercises)	Upright Rows	3	X	6
Forearms-Flexor Digitorum Superficialis (perform after bicep exercises)	Wrist Curls	3	X	6

* Rest 2-4 minutes between sets.

* Perform program 3 times per week with a minimum of 48 hours rest in between workouts.

* Load (6 RM--maximum amount of weight that can be lifted for six repetitions)

* Perform stretching exercises prior to executing the workout. No particular stretching exercises are recommended but the entire body should be stretched in some fashion. For additional information on types of stretching exercises, see FM 21-20 or any other physical fitness manual containing these types of exercises or movements.

- * Perform at least one warm-up set immediately preceding each exercise for a minimum of six repetitions at 50 percent of 6 RM.

If the lifter is not loosened-up after stretching and performing a warm-up set, additional warm-up sets can be performed. However, if the lifter performs too many warm-up sets, the 6 RM sets will be degraded.

- * Train abdominals at the conclusion of the workout or on non-weight training days.

To avoid boredom, one should periodically add variety into the workout. This can be accomplished through several means. One technique is to substitute the basic exercises in the proposed program with alternate exercises that work the same muscles. Table 11 shows both primary and alternate exercises for each body part. Another technique is to change the number of sets and repetitions. However, if the number of sets and repetitions are increased, the outcome focuses on endurance rather than strength.

The muscle groups that should be worked are the pectoralis majors, latissimus dorsi, rectus femoris, biceps femoris, gastrocnemius, triceps, biceps, deltoids, trapezius, and flexor digitorum superficialis since all these muscles are used by the tank crewman to perform his job.

TABLE 11

PRIMARY AND ALTERNATE EXERCISES

PER BODY PART

<u>Body part-Muscles</u>	<u>Primary</u>	<u>Alternate or Substitute</u>
Legs-Rectus and Biceps femoris	Squats	Leg curls and Extensions Front Squats Leg Press Hack Squats Lunges
Chest-Pectoralis majors	Bench press	Dumbbell Flies Dips Pullover
Incline Press		
Back-Latissimus dorsi	Bent-over-rows	Chinups Lat Pulldowns
Shoulders-Deltoids	Overhead Press	Side Lateral Raises
Upper Back-Trapezius	Upright Rows	Shoulder Shrugs
Rear Upper Arm-Triceps	Supine Triceps Extensions	Dumbbell Triceps Extensions
Front Upper Arm-Biceps	Biceps Curl (dumbbells)	Biceps Curl (barbell)

*See Appendices A-I for description and diagram of exercises. Narratives for the exercises from Strength Training by the Experts, edited by Riley, an excerpt from Chapter 11 by Peterson. Diagrams from "Bruce Algra Charts."

Recommendations

The weight training program which I propose has not been validated. I recommend that this program be validated to ensure that it produces the desired results. I recommend that the United States Army Armor Center (USAARMC), as the proponent for CMF 19 and SC 12 training material, take the lead in validating this program by testing it on personnel assigned there. Furthermore, I recommend USAARMC test this program using free weights, Nautilus, and Universal machines to determine which produces the greatest strength gains. I also recommend further study on the impact of age, duration of the program, and sustainment or what it takes to maintain strength levels.

Upon validation, the Army might consider formalizing the proposed weight training program as a technique, sample, or option to gain strength by including it in a revision of FM 21-20, Physical Fitness Training. It could be tailored by commanders to fit the unit's requirements. As a minimum, I hope this study may be used as a genesis for future studies on weight training and strength development for Armor crewmen.

APPENDIX A: OVERALL BODY DEVELOPMENT
EXERCISE

DEAD LIFT

Muscles Used: Primary and secondary-All

Equipment: Barbell

Execution of the Exercise: Using a barbell, place feet approximately shoulder width apart under the bar. Hands should be placed just outside the legs with palm facing forward on one hand and palm facing inward on the other hand. With the back straight and head up, inhale deeply. Exhale as the barbell is lifted to the standing position. Arms should be fully extended at sides. Lower the weight to the floor and repeat.

Safety: The legs should be used during the lift. This puts less strain on the back by distributing the work between the back and legs more effectively. Keep the back straight throughout the conduct of the exercise to prevent injury to the lower back.

Key Point: - When lifting the weight, concentrate on raising the chest up. This will assist the lifter in raising the weight.

NO DIAGRAM AVAILABLE

APPENDIX B: LEG EXERCISES

SQUATS

Muscles Used: Primary-Rectus Femoris, Vastus Medialis,
Vastus Lateralis, Biceps Femoris
Secondary-Gluteus Maximus

Equipment: Barbell, Squat Rack(s)

Execution of the Exercise: Assume the starting position with feet approximately shoulder width apart, barbell resting on the back of the shoulders. Lower the buttocks until the thighs are at least parallel to the floor and recover to the starting position.

Safety: The spotter should remain as close as possible behind the lifter without disturbing the lift. If the lifter needs assistance in raising the weight to the starting position, the spotter should place his arms around the lifter's chest and pull up until the lifter is in the upright position. This can prevent injury to the lower back.

Key Points: - When executing the squats, keep the back as straight as possible to keep emphasis on the legs.

- Look upward when performing the exercise.

This will help keep the back straight.

- Do not bounce while coming out of the squat position. This will prevent injuries to the knees.

- See figure 6

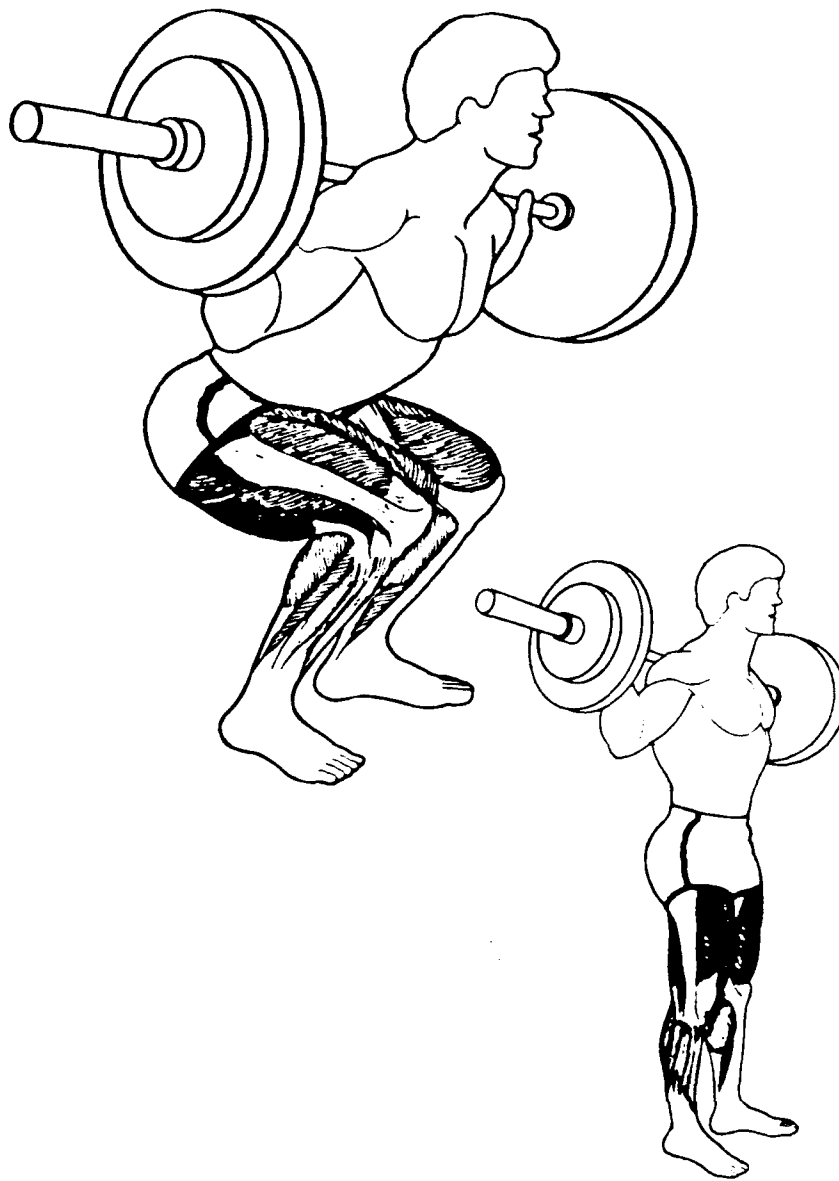


FIGURE 6

LEG CURLS

Muscles Used: Primary-Biceps Femoris
Secondary-Gastrocnemius

Equipment: Leg Curl Machine (Universal or Nautilus)

Execution of the Exercise: Lie face down on the bench of the leg curl machine. Position the heels of the feet behind the foot supports, arch the back slightly and position the elbows on the bench near the chest area. Using the hamstring muscles, raise the weight to the hip area. Slowly lower the weight while returning to the starting position.

Safety: To maximize the effect of the exercise, avoid lifting the buttocks off the bench when contracting weight.

Key Points: - If the lifter cannot fully contract the hamstrings, the spotter should assist the lifter by raising his ankles.

- See figure 7

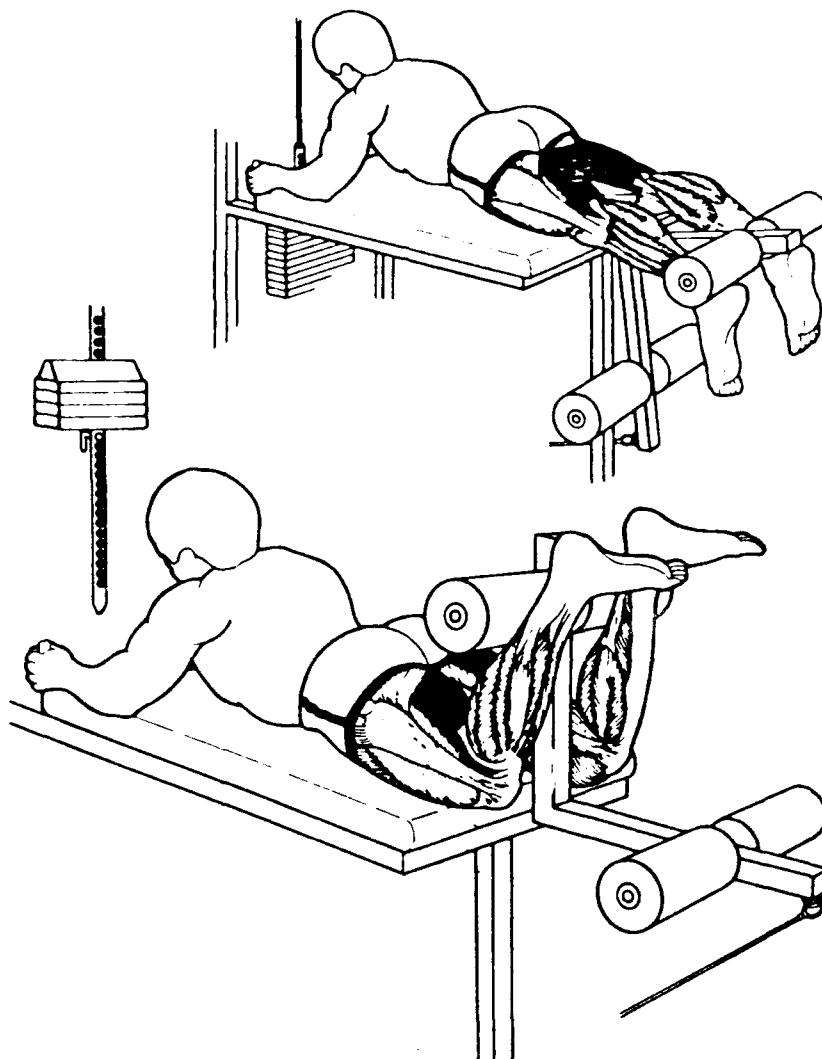


FIGURE 7

FRONT SQUATS

Muscles Used: Primary-Rectus Femoris, Vastus Medialis,
Vastus Lateralis

Secondary-Gluteus Maximus and Biceps Femoris

Equipment: Barbell, Squat Rack(s)

Execution of the Exercise: Position a barbell on the front of the shoulders. Cross the arms and grasp the bar to prevent it from falling off the shoulders. With the back erect, lower the weight and upper body while bending at the knees. Once a 90 degree angle is achieved, or the thighs are parallel to the floor, raise the weight and upper body to the starting position. Prior to the descent take a deep breath and exhale as the ascent begins. Do not hold your breath during the execution of this exercise.

Safety: The spotter should remain as close as possible behind the lifter as close as possible to him without disrupting the lift. If the lifter needs assistance in raising the weight to the starting position, the spotter should place his arms around the lifter's chest and pull up until the lifter is in the upright position. This can prevent injury to the lower back.

- Key Points:
- When executing the squat, keep the back as straight as possible to keep emphasis on the legs.
 - Look upward when performing the exercise.
 - Do not bounce while coming out of the squats position. This will prevent injuries to the knees.
 - When ascending, it is particularly important to exhale.
 - See figure 8

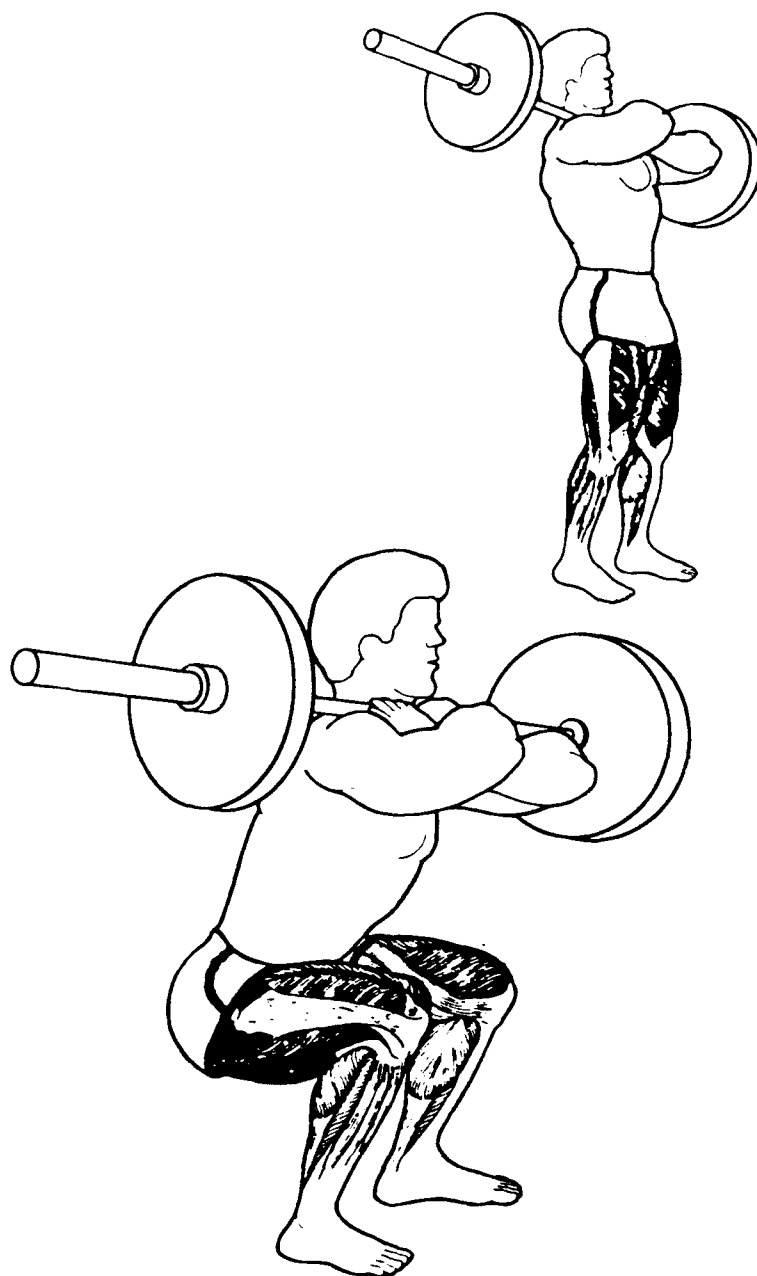


FIGURE 8

LEG PRESS

Muscles Used: Primary-Rectus Femoris, Vastus Medialis,
Vastus Lateralis, Biceps Femoris
Secondary-Gluteus Maximus

Equipment: Universal Gym or Leg Press Machine

Execution of the Exercise: While a seated position, place feet on the foot platform. Using the thighs, raise the weight slightly. Use the hands to release the locking mechanism which holds the platform and weight in a neutral position. Using the thighs, slowly lower the weight to where the back of the thigh touches the calf muscle. Press the weight back to the starting position.

Safety: To minimize stress on the knees, avoid bouncing or jerking the weight while executing the exercise.

Key Points: - To keep constant resistance on the legs, do not allow the legs to fully lock out.
- See figure 9

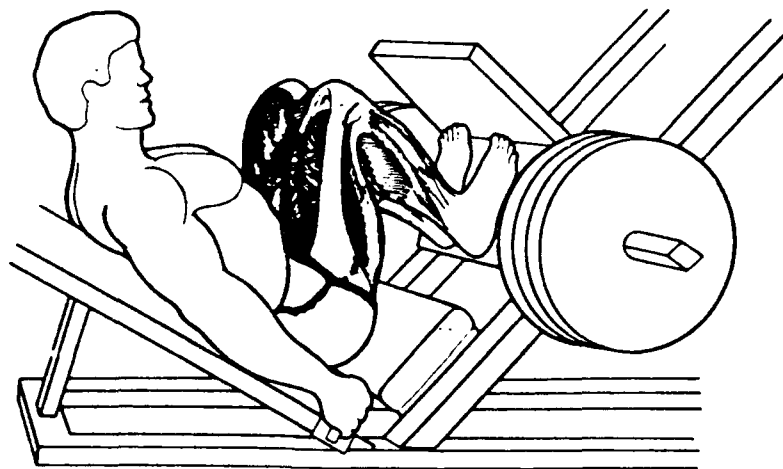
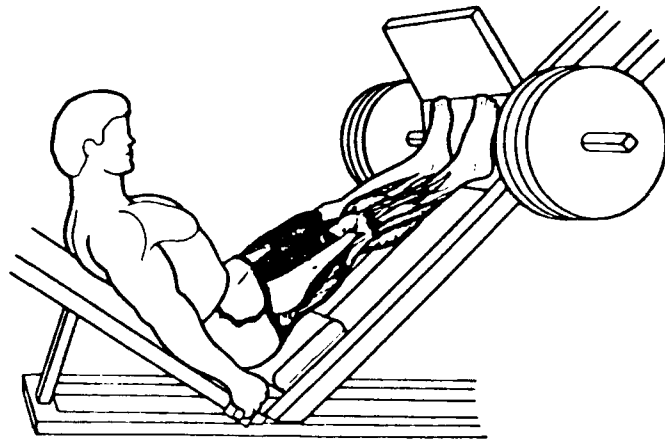


FIGURE 9

HACK SQUATS

Muscles Used: Primary-Rectus Femoris, Vastus Medialis,
Vastus Lateralis, Biceps Femoris
Secondary- Gluteus Maximus

Equipment: Hack Squat Machine

Execution of the Exercise: Begin in a standing position.
Place the feet on the foot platform. Slowly lower the upper
torso to where the thighs are parallel with the foot
platform. With the back straight, use the thighs to raise
the upper torso and weight to the starting position.

Safety: To minimize stress on the knees, avoid bouncing or
jerking the weight while executing the exercise.

Key Point: - See figure 10

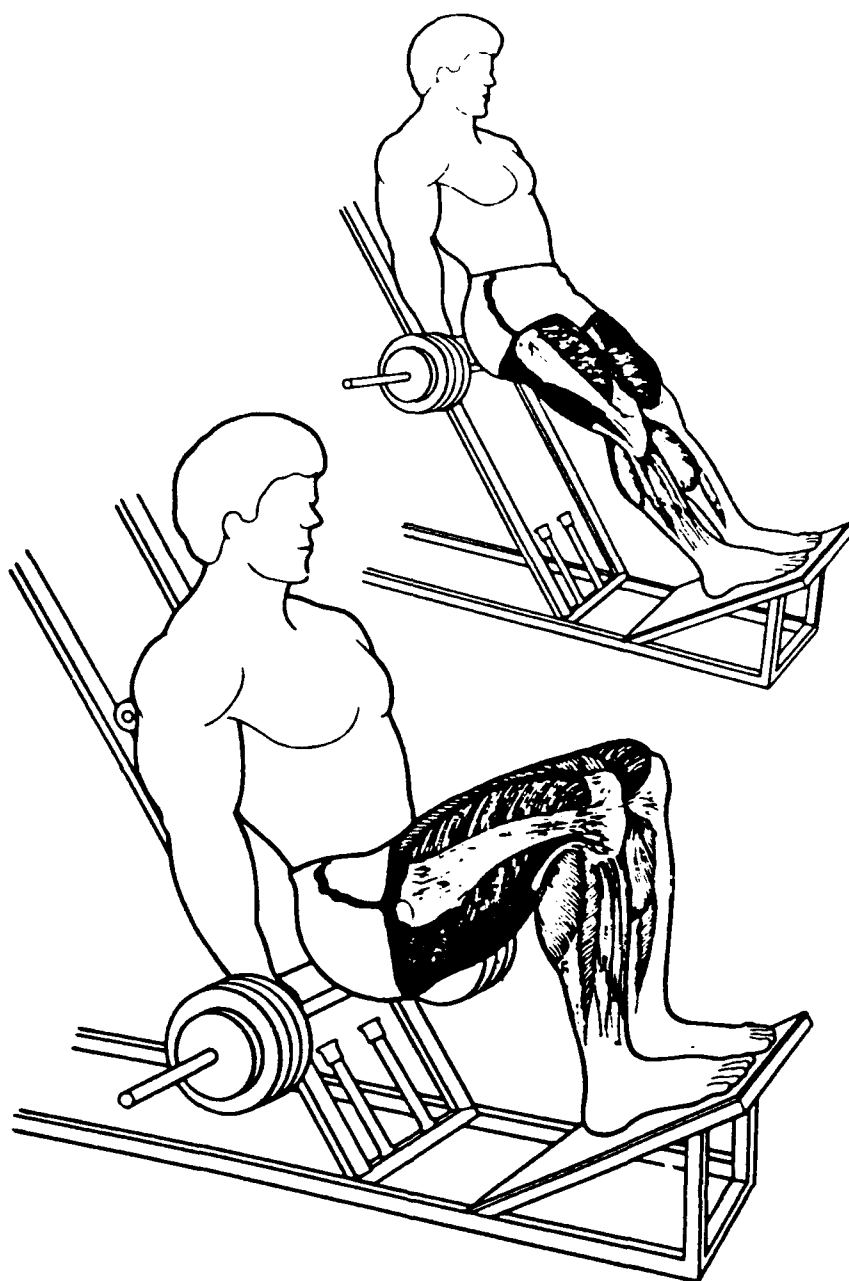


FIGURE 10

LEG EXTENSIONS

Muscles Used: Primary-Rectus Femoris, Vastus Medialis

Equipment: Leg Extension Machine

Execution of the Exercise: While sitting on the extension machine, tuck the tops of the ankles under the foot support pads. Slowly raise the legs until they are completely extended. Pause momentarily while squeezing the quadriceps. Lower the legs to the beginning position.

Safety: Do not jerk or bounce the weight while conducting the exercise. This will reduce injury to the joints.

Key Points:

- Keep the buttocks on the bench.
- Do not bounce or jerk the weight up to reduce injury to the joints.
- Execute the movement slowly.
- See figure 11

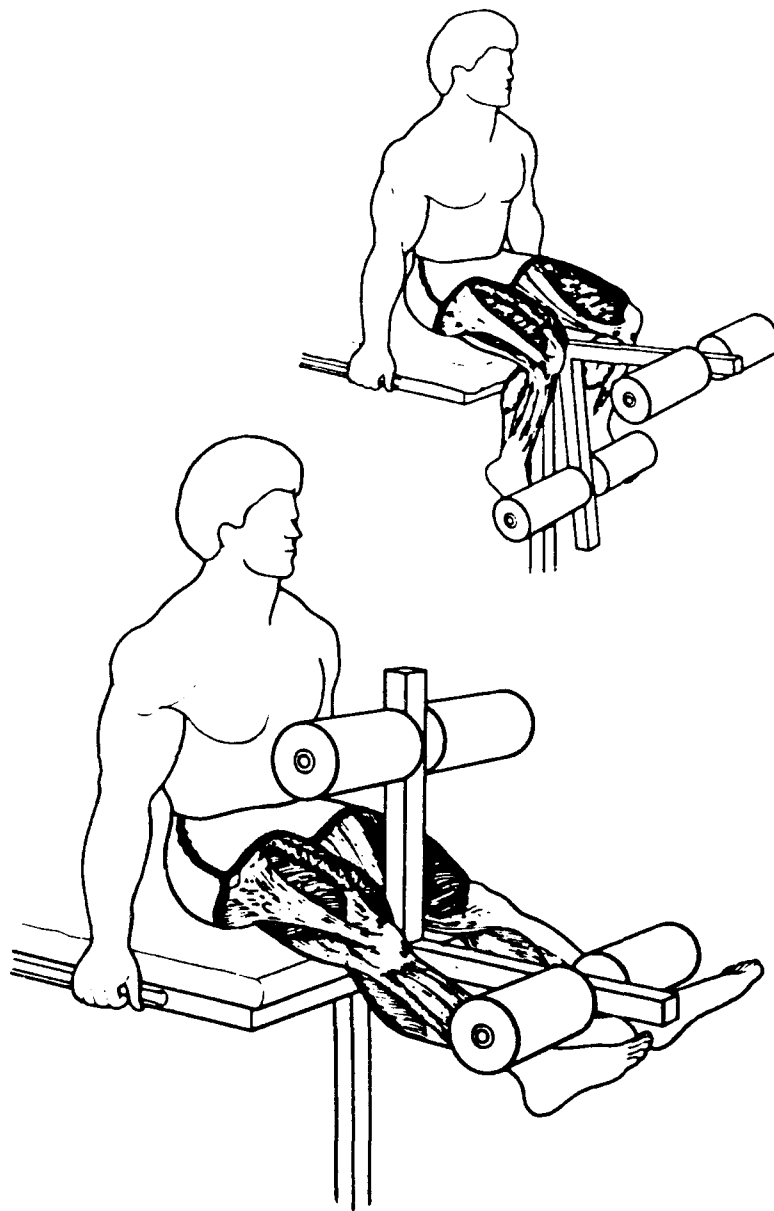


FIGURE 11

LUNGES

Muscles Used: Primary-Rectus Femoris, Vastus Medialis,
Vastus Lateralis, Biceps Femoris
Secondary- Gluteus Maximus

Equipment: Barbell or Dumbbell

Execution of the Exercise: Position a barbell on the trapezius muscle while standing with feet shoulder width apart. Keep one leg stationary for support while stepping forward with the other leg until the thigh is parallel to the ground. Insure the upper torso is erect throughout the exercise. After the parallel position has been reached, raise the weight back to the starting position. Alternate legs after each repetition.

Safety: Do not bounce when executing this exercise. When stepping forward, do not take an excessively long step. This will avoid injury to the knee.

Key Points: - If a barbell is unavailable, dumbbells may be substituted. If dumbbells are used, hold them, while in a standing position, in the hands along the contour of the body.

- Continue as described in "Execution of the Exercise."

- See figure 12

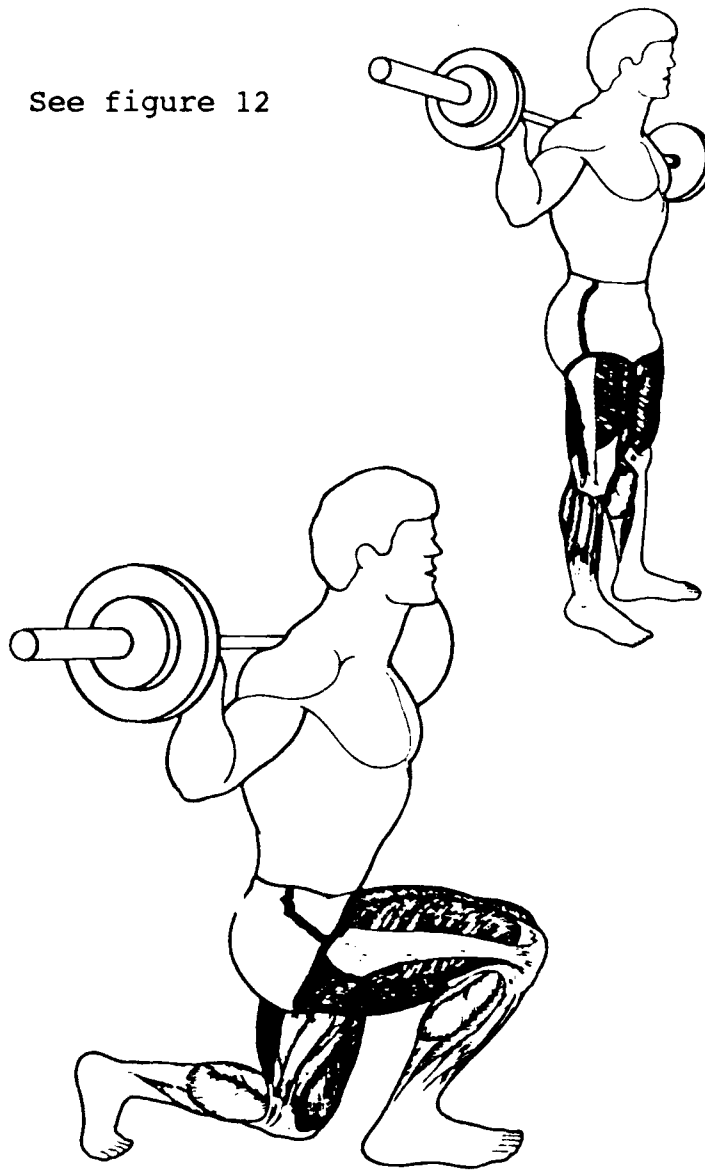


FIGURE 12

CALF RAISES

Muscles Used: Primary-Gastrocnemius and Soleus

Equipment: Barbell or Calf Machine

Execution of the Exercise: While sitting on the calf machine, place the balls of the feet on the foot support platform. Slide the knees underneath the knee support pads. Raise the calf muscles, using the balls of the feet, until they are fully extended. To complete the exercise, lower the weight until the heels are below the balls of the feet.

Key Points: - Lift the heel as high as possible when raising the weight.

- Perform the exercise slowly and ensure to lower the weight below the balls of the feet.

- See figure 13

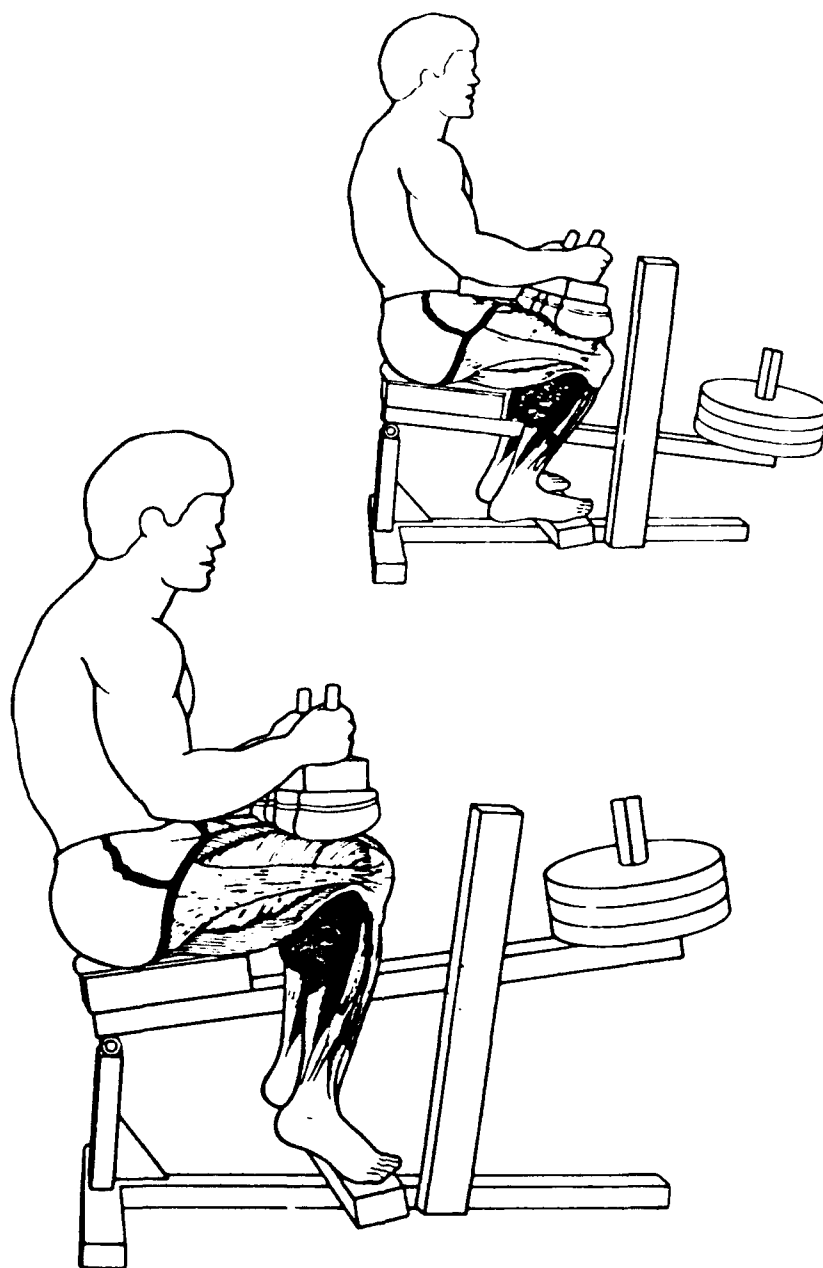


FIGURE 13

APPENDIX C: CHEST EXERCISES

BENCH PRESS

Muscles Used: Primary-Pectoralis Majors

Secondary-Deltoids and Triceps

Equipment: Flat Bench (parallel to ground) with Rack and Barbell or Universal Gym

Execution of the Exercise: Assume the supine position upon an exercise bench with a barbell positioned on the rack overhead. Place hands slightly more than shoulder width apart with palms facing the ceiling. Lift the weight from the rack inhaling as the weight is lowered to the chest. As the weight is lowered, ensure that the elbows remain out to isolate the chest. If the elbows are brought in, the triceps will be emphasized more than the chest. Exhale while barbell is pressed towards the ceiling. Arms should be completely extended. Lower bar to the chest and repeat.

Safety: The spotter can assist the lifter in lifting the weight off the rack. If the lifter cannot fully extend his arms on a repetition, the spotter can assist him by supporting the lifters elbows until the repetition is completed. The spotter must pay close attention to ensure that heavy weights are not lowered to the lifters chest to

quickly. The spotter may also place his hands on the bar to assist the lifter in raising the weight.

Key Points: - To avoid chest injury, do not bounce the weight off the chest.

- When the weight is pressed the weight to the fully extended position, the barbell should be raised slightly over the eyes.

- To prevent injury to the lower back, do not arch the back.

- When lowering the weight to the chest, try to touch the bar to the nipple region of the chest.

- See figure 14

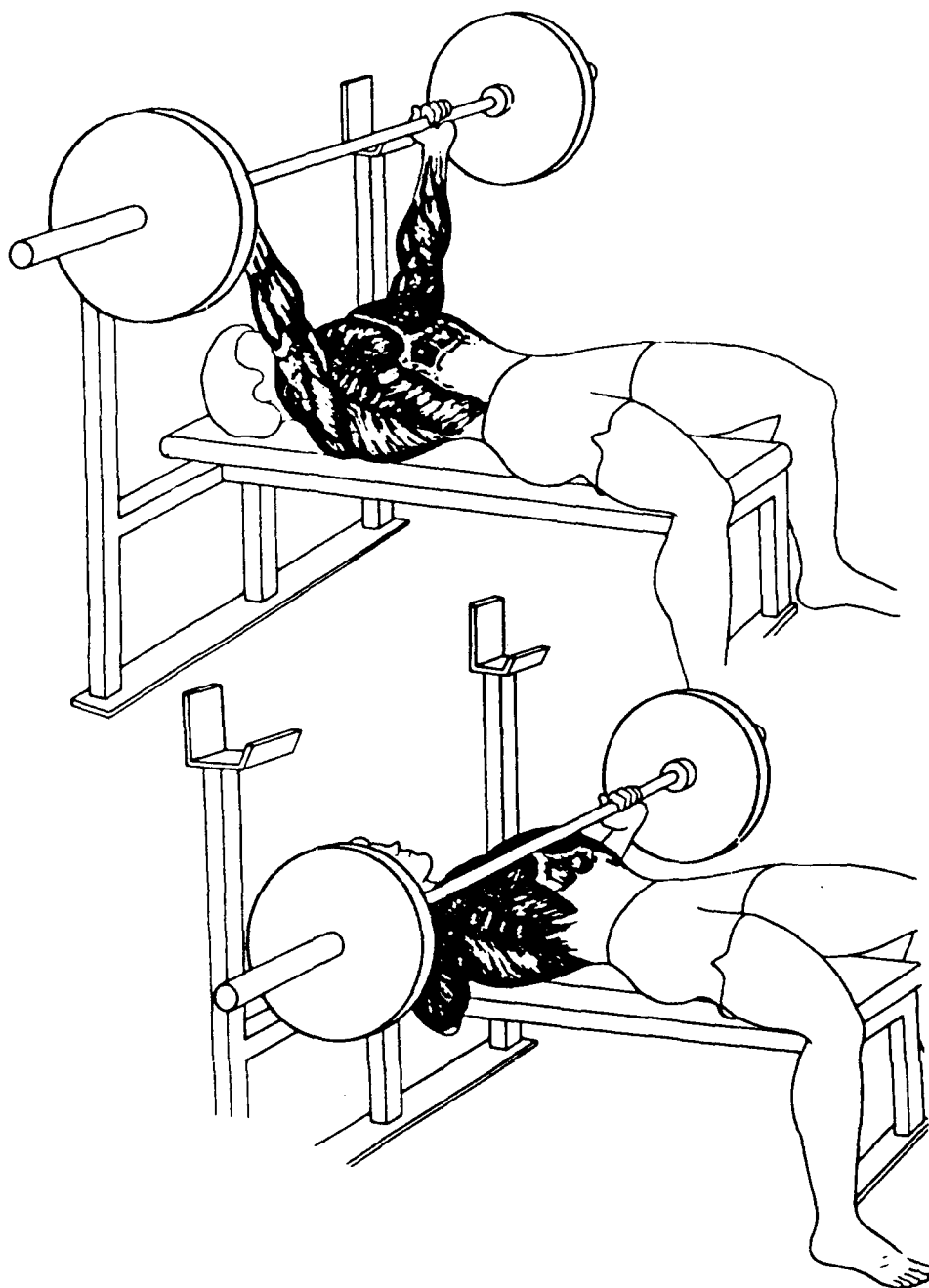


FIGURE 14

INCLINE PRESS

Muscles Used: Primary-Pectoralis Majors

Secondary-Deltoids and Triceps

Equipment: Incline Bench, Barbell or Dumbbells

Execution of the Exercise: Lie on an incline bench with a barbell positioned on the bench rack. Grasp the barbell, and lift the weight off the rack. Lower the barbell to the top of the chest then raise the weight until the arms are fully extended.

Safety: The spotter should position himself behind the lifter to give assistance as required. Perform this exercise slowly to avoid damage to the elbows.

NO DIAGRAM AVAILABLE

DIPS

Muscles Used: Primary-Pectoralis Major
Secondary-Triceps and Deltoids

Equipment: Dip Bars

Execution of the Exercise: Using the arms, raise the body on the dip bars until the arms are fully extended. Lower the body by bending the arms at the elbow. When the body is as low as it can go, raise it until the arms are fully extended again.

Safety: Lower the body as slowly as possible to prevent injury to the elbows. Be sure to breathe during this exercise. Inhale as the body descends and exhale as the body ascends.

Key Points: - In order to achieve a full range of motion, bend the knees slightly during the execution of the exercise.

- To add stress to the body, strap additional weight to the body before performing the sets.

- See figure 15

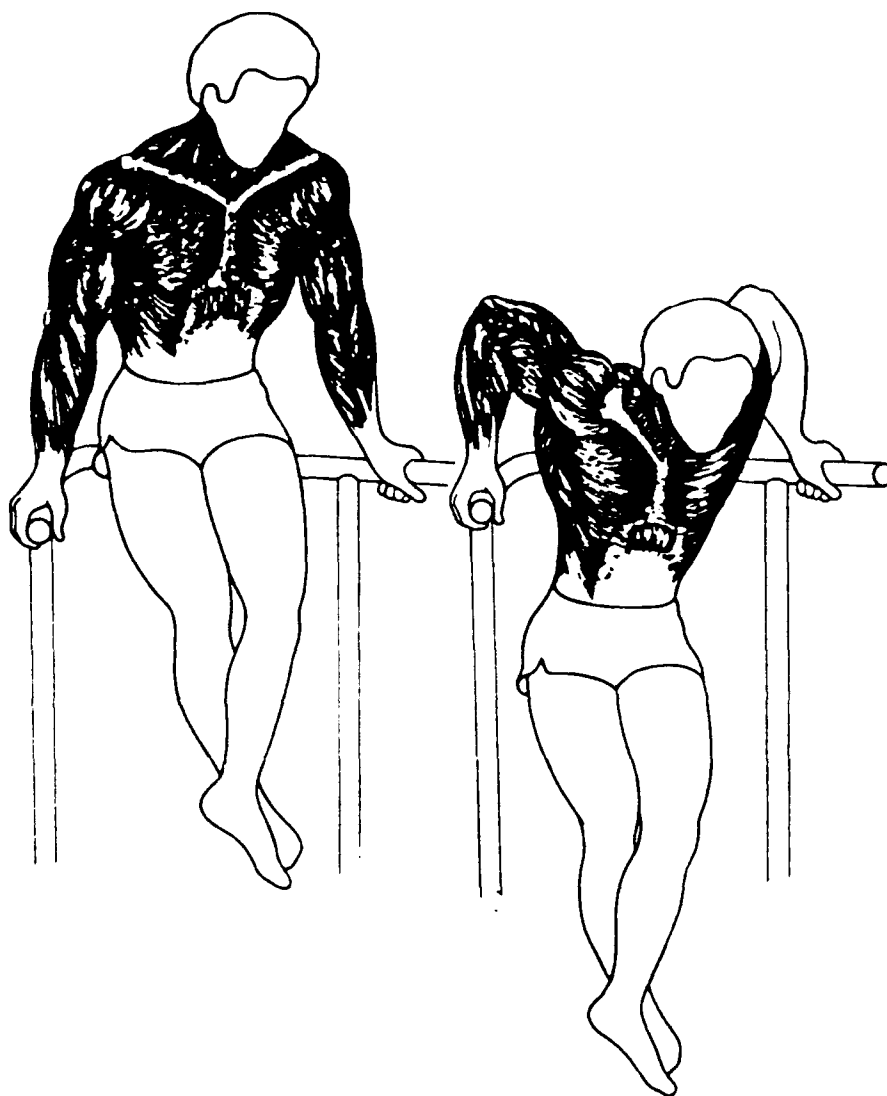


FIGURE 15

DUMBBELL FLIES

Muscles Used: Primary-Pectoralis Majors
Secondary-Deltoids

Equipment: Exercise Bench, Incline or Decline Bench,
Dumbbells

Execution of the Exercise: Lie on the exercise bench. Grasp a dumbbell in each hand. Raise the weight to the chest area. Continue to raise the dumbbells until the arms are fully extended. Lower the weight to stretch the pectorals then raise the weight again until the arms are fully extended away from the body. The exercise should be performed with palms facing towards each other.

Safety: To prevent damage to the elbows, keep the arms semi-flexed.

Key Points: - To maximize the effects of the exercise, the pectoralis majors should be stretched as much as possible when the weight is lowered.

- See figure 16

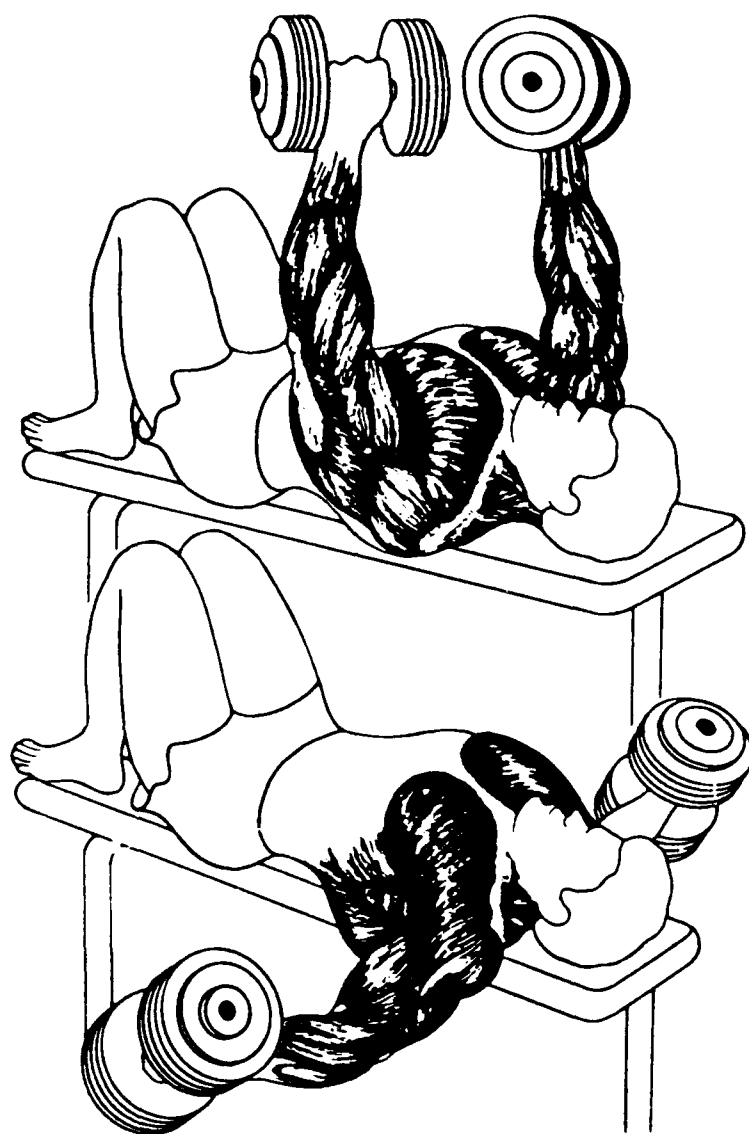


FIGURE 16

BENT ARM PULLOVERS

Muscles Used: Primary-Pectoralis Majors

Secondary-Latissimus Dorsi and Deltoids

Equipment: Exercise Bench, Barbell or Dumbbell

Execution of the Exercise: Lie perpendicular on an exercise bench with back flat and neck and head extended over the edge of the bench. The feet should be flat on the floor. Position a dumbbell on top of the rib cage just below the neck. Lower the bar over the head, toward the floor such that the dumbbell comes as close as possible to the chin, forehead and the top of the head, then raise the weight back to the rib cage.

Safety: The spotter should place the dumbbell in the starting position for the lifter. The lifter may decide to lower the dumbbell to the floor prior to raising it back and to the rib cage. When the exercise is completed, the spotter should take the dumbbell from the lifter and place it on the floor. The spotter should pay particular close attention as the weight is lowered over the face to prevent injury.

Key Point: - See figure 17

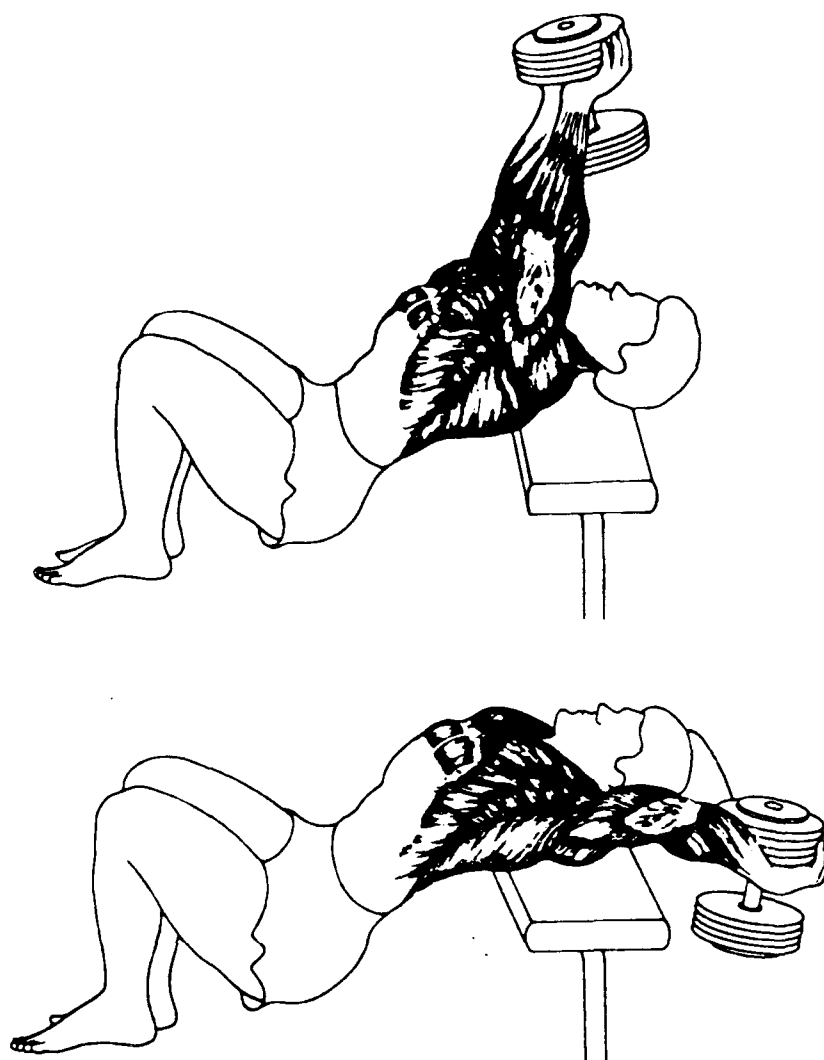


FIGURE 17

APPENDIX D: BACK EXERCISES

BENT-OVER-ROWS

Muscles Used: Primary- Latissimus Dorsi

Secondary- Trapezius, Deltoids, Biceps

Equipment: Barbell

Execution of the Exercise: Place feet approximately shoulder width apart. Bend over the barbell with legs straight and back parallel to the floor. Grasp barbell with palms facing inward. Raise the bar slightly off the ground to a hanging position. To begin the exercise, exhale as you pull barbell from the hanging position to the chest. Inhale as you lower the bar back to the hanging position. This exercise should be done with the arms and back only. A rowing motion used be used.

Safety: Keep the body stiff and in a bent position to avoid injury to the lower back.

Key Points:

- Bend the body at the hips. Do not bend forward at the waist when pulling the weight downward.
- Raise and lower the weight slowly to avoid injury.
- See figure 18

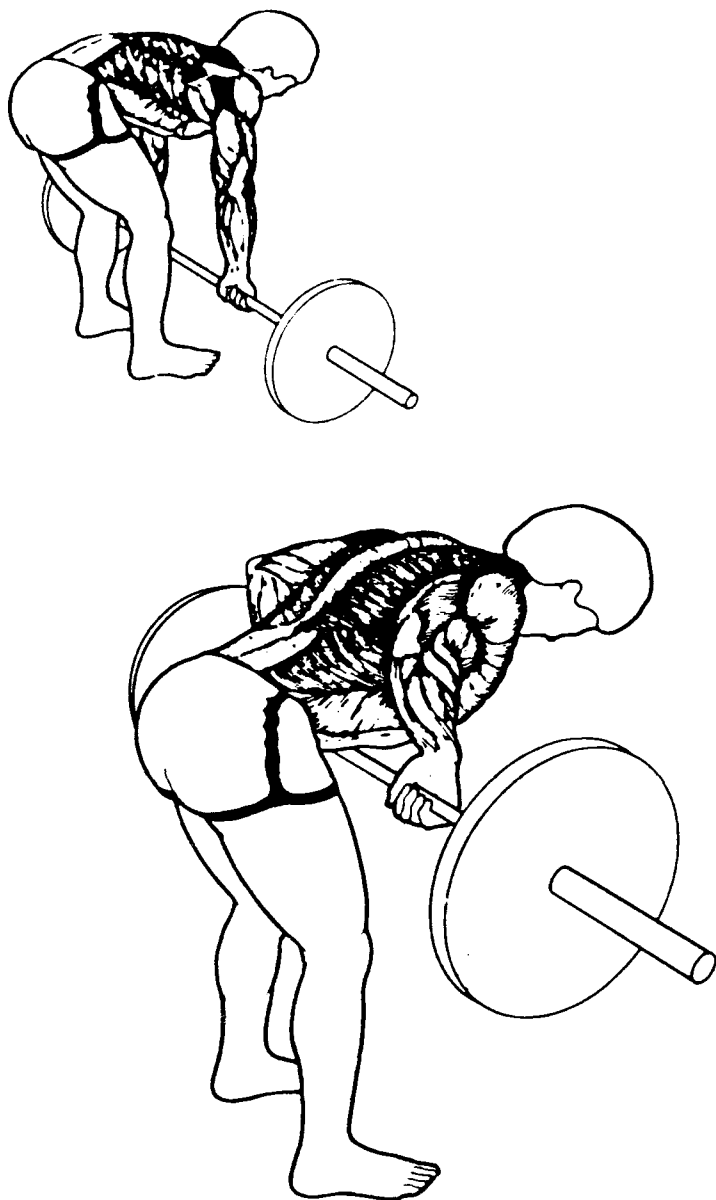


FIGURE 18

CHINUPS

Muscles Used: Primary-Latissimus Dorsi
Secondary- Biceps and Triceps

Equipment: Chinup Bar

Execution of the Exercise: Grasp a chinup bar with an underhand grip, palms facing away from the body and arms fully extended. Raise the body upward so the chin is lifted over the bar, then lower the body to the starting position.

Safety: Exhale as the body is raised. Inhale as the body is returned to the starting position. Make sure to breathe during this exercise.

Key Points:

- To increase strength and mass, additional weight can be strapped to the lifter.
- Grip the hands shoulder width apart so the emphasis is on the latissimus dorsi.
- For maximum development, concentrate on lowering the body slowly.
- This exercise may be performed with an overhand grip to focus on tricep development.
- See figure 19

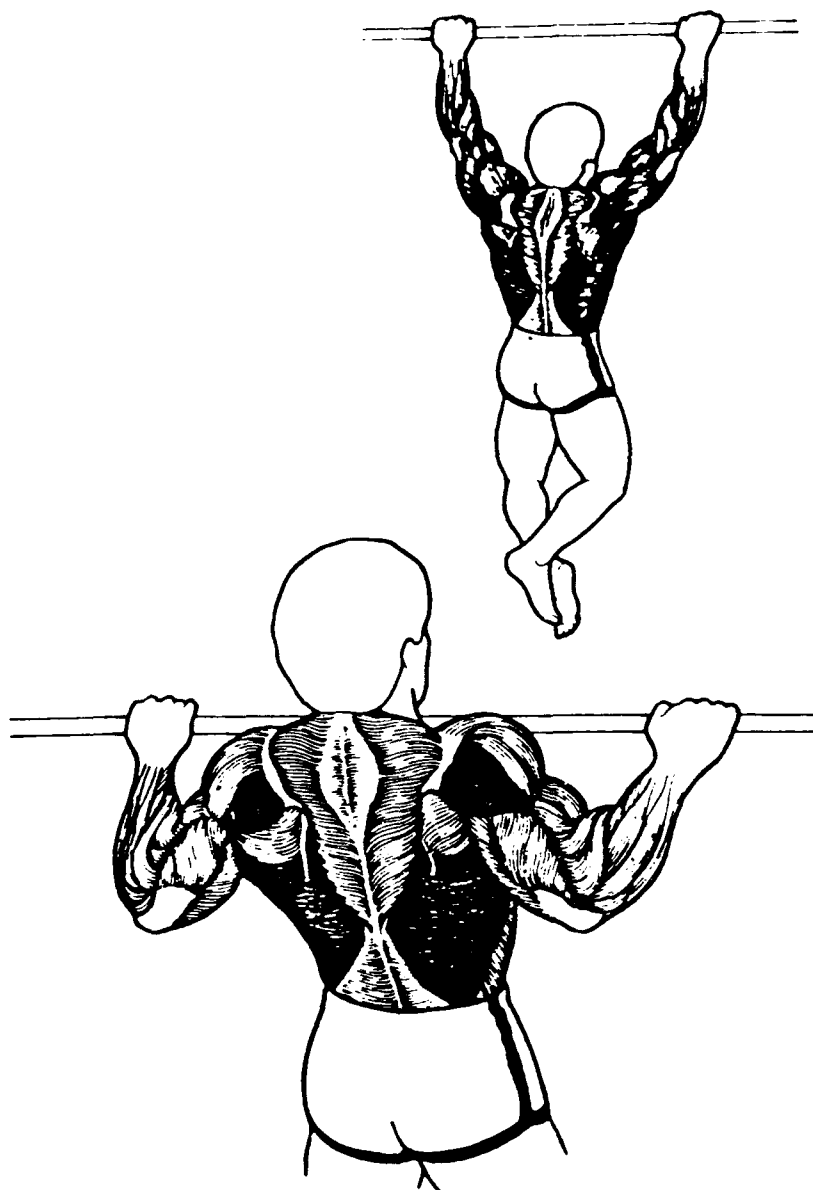


FIGURE 19

LAT PULLDOWNS

Muscles Used: Primary-Latissimus Dorsi
Secondary-Biceps and Deltoids

Equipment: Lat Machine

Execution of the Exercise: Kneel or sit on the floor so the rear of the neck is directly under the bar of the lat machine. Pull the bar down, using an overhand grip, to the base of the rear of the neck. Pause briefly then resist the weight as it returns to the starting position. Inhale while pulling the bar down. Exhale while returning to the starting position.

Safety: A spotter can apply pressure to the shoulders of a lifter using heavy weights to prevent the lifter from rising from his position. Execute the exercise slowly. Alternatively, a seat with leg locks may be used. The lifter should insert his legs beneath the supports.

Key Points: - A lifter may vary the execution of this exercise by pulling the weight down in front of the neck area.

- The lifter can use a close grip with either an underhand or overhand grip.

- The underhand grip emphasizes the biceps more than the overhand grip.

- See figure 20

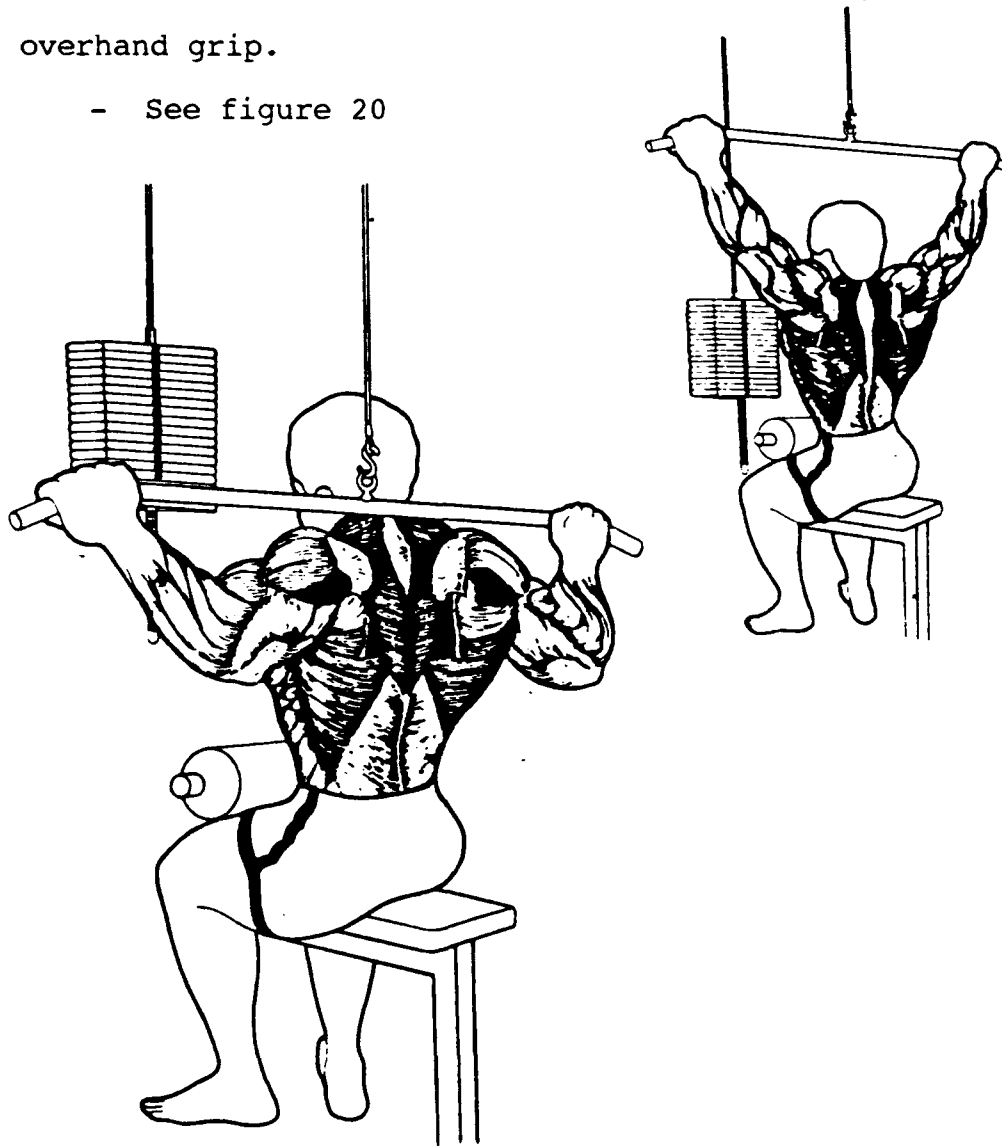


FIGURE 20

APPENDIX E: SHOULDER EXERCISES

OVERHEAD PRESS

Muscles Used: Primary-Deltoids
Secondary-Triceps

Equipment: Barbell or Universal Gym

Execution of the Exercise: Grasp the barbell using an overhand grip that is slightly beyond shoulder length. The palms should face outward. Position the feet approximately shoulder length apart beneath the bar. Inhale deeply as the weight is lifted to the shoulders. Keeping the elbows up and forward. This is the starting position. With the back and legs rigid, exhale while the weight is pressed overhead and the arms are fully extended. Slowly lower the weight to the starting position.

Safety: The spotter should stand behind the lifter to assist him in lifting the weight if necessary. Leaning back while extending the arms creates additional stress that can injure the lower back.

Key Points: - Dumbbells may be substituted for a barbell if the lifter desires.

- The elbows can be placed directly beneath the bar if the lifter desires.

- To prevent cheating, do not lean back when extending the arms.

- See figure 21

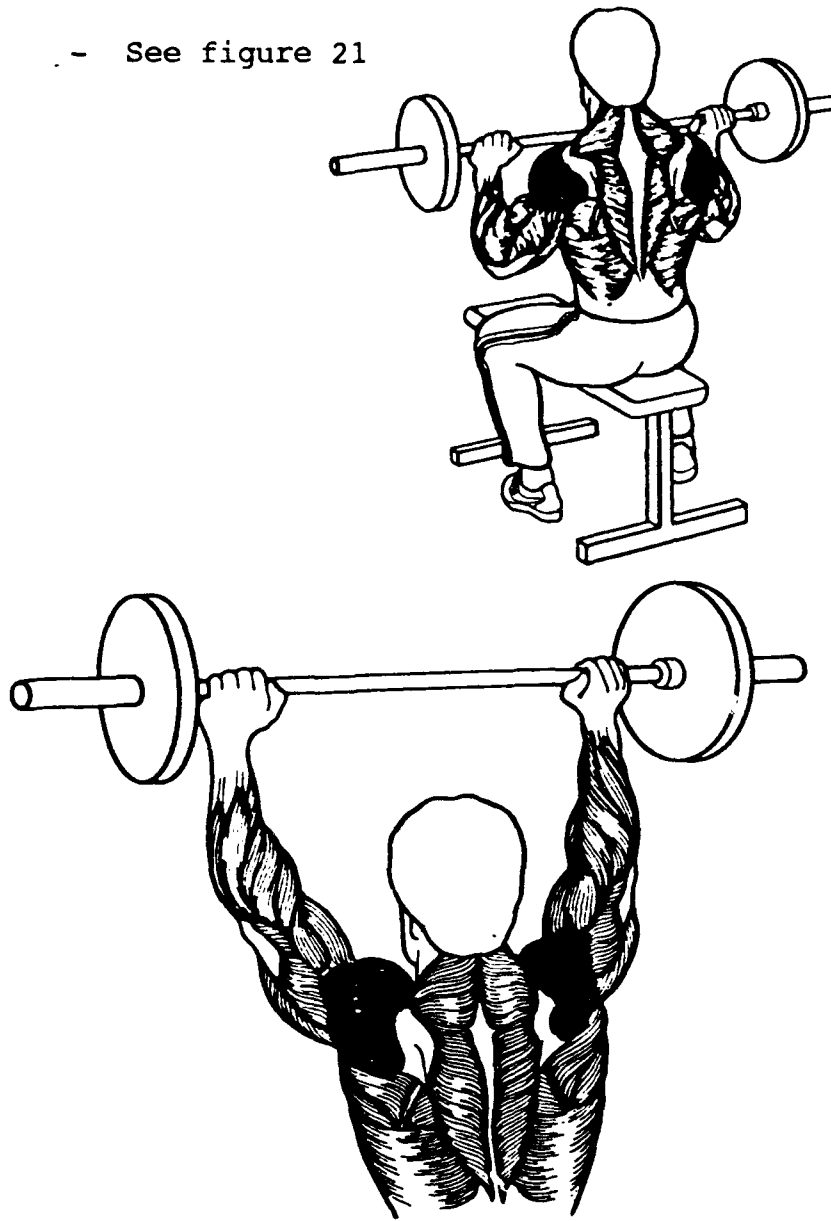


FIGURE 21

SIDE LATERAL RAISES

Muscles Used: Primary-Deltoids
Secondary-Trapezius

Equipment: Dumbbells

Execution of the Exercise: Bend the body slightly forward at the waist. Extend the arms down along the sides of the legs, palms facing each other. Grasp a pair of dumbbells and raise them sideward and upward so they are parallel with the head, palms facing the ground. Pause briefly then slowly return to the starting position. Exhale while raising the weight and inhale when lowering the weights.

Key Points: - A spotter can apply additional resistance (manually) to the lifter's hands while he raises the dumbbells sideward and upward.

- See figure 22

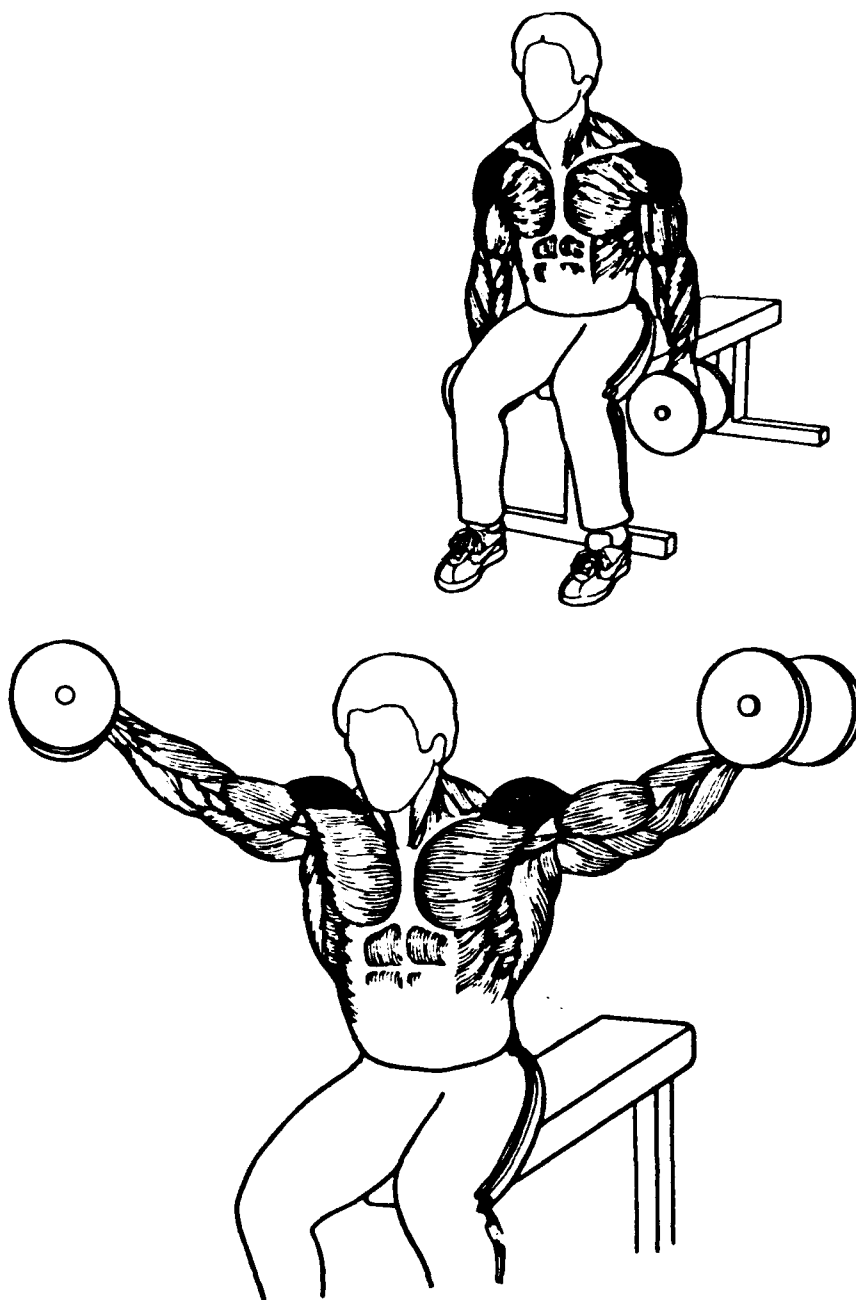


FIGURE 22

APPENDIX F: TRAPEZIUS EXERCISES

UPRIGHT ROWS

Muscles Used: Primary-Trapezius
Secondary-Deltoids

Equipment: Barbell or Universal Gym

Execution of the Exercise: Stand with arms extended downward grasp the barbell with both hands. The grip should slightly be less than shoulder width. Feet should be shoulder width apart. Raise the barbell upward until the bar touches the throat area, pause briefly and slowly return to the starting position. Exhale as the weight is raised. Inhale as the weight is lowered.

Key Points:

- Make sure the back remains straight.
- Raise the weight with the trapezius and shoulders and not the arms.
- See figure 23

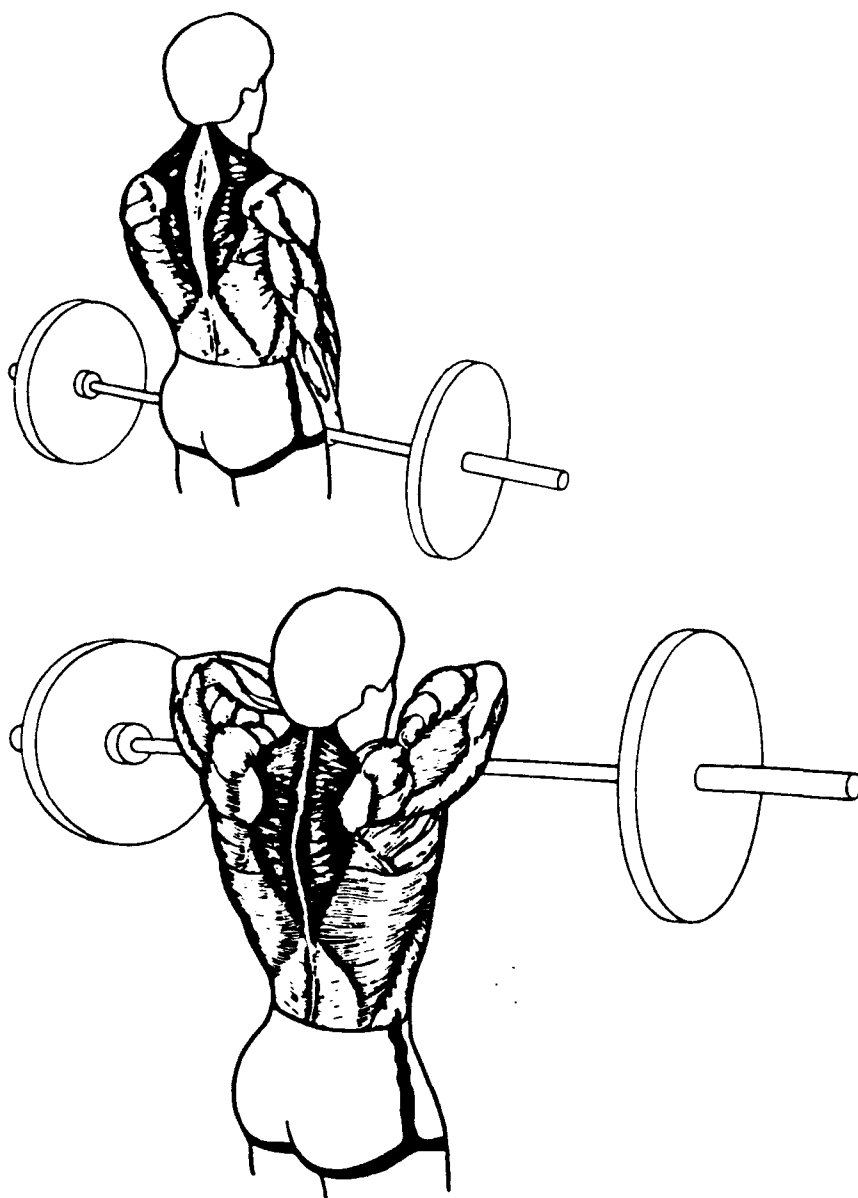


FIGURE 23

SHOULDER SHRUGS

Muscles Used: Primary-Trapezius
Secondary-Deltoids

Equipment: Barbell, Universal Gym, or Dumbbells

Execution of the Exercise: With feet approximately shoulder width apart and arms extended at each side, hold the barbell across the upper thighs with palms facing inward. This is the starting position. The shoulders are raised and back as far as possible. Lower the shoulders to the starting position and repeat. To vary this exercise, rotate or perform a circular motion shrugging the shoulders upward then back and forward.

Safety: Raise and lower the weight slowly to avoid injury. Use the shoulders and trapezius to raise the weight.

Key Point: - Keep the arms straight when lifting the weight.

NO DIAGRAM AVAILABLE

APPENDIX G: TRICEP EXERCISES

TRICEPS EXTENSION

Muscles Used: Primary-Triceps
Secondary-Deltoids

Equipment: Barbell, Curl Bar, Dumbbell, Exercise Bench

Execution of the Exercise: Stand with feet comfortably apart, back and legs straight. Grasp the barbell with hands placed slightly more than shoulder width apart, palms facing inward. Use an overhand grip. Raise the barbell to the shoulders. Exhale as the barbell is pressed overhead until the arms are fully extended. The barbell is now in the starting position. Inhale and lower barbell behind the neck with the elbows pointed up and out. Exhale and raise the weight back to the starting position.

Safety: The spotter should hand the weight to the lifter when he assumes the starting position and remove the weight from the lifter when the set is completed.

Key Points: - Arms should be kept at shoulder width and bent at the elbows.
- The triceps should remain perpendicular to the floor.

- This exercise may be performed in a standing or seating position.

- See figure 24

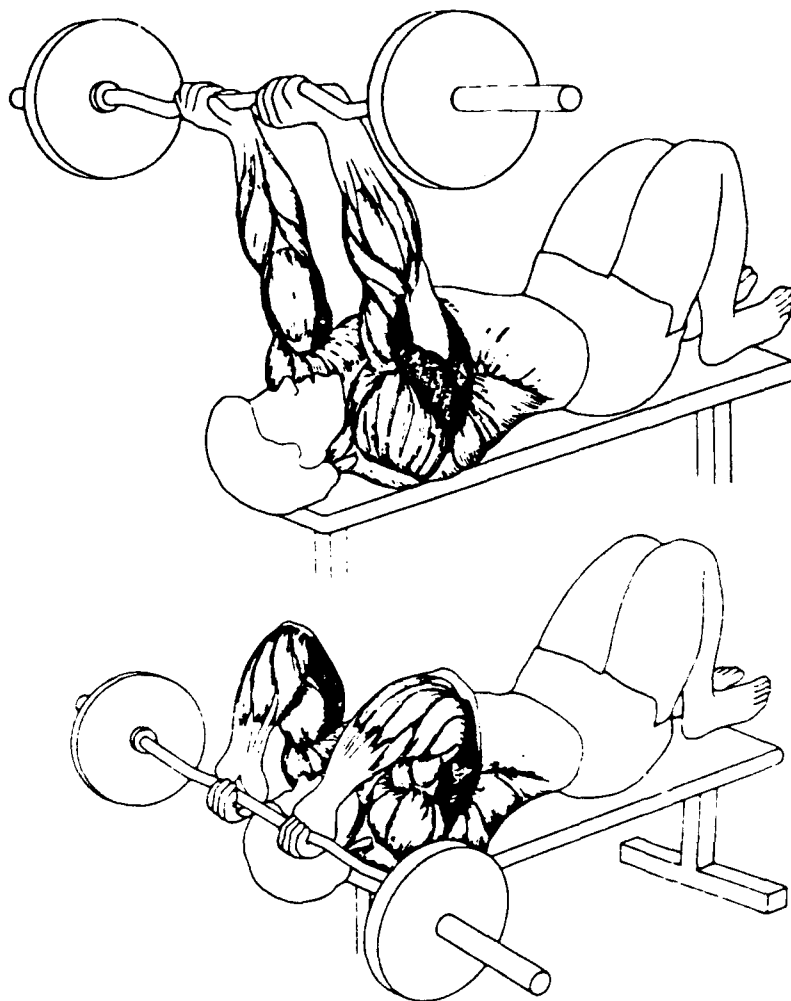


FIGURE 24

APPENDIX H: BICEP EXERCISES

BICEPS CURL

Muscles Used: Primary-Biceps

Secondary-Forearms

Equipment: Dumbbells, Barbell, or Universal Gym

Execution of the exercise: With feet approximately shoulder width apart and arms extended at side, reach down, palms facing forward, to grasp a pair of dumbbells. Raise the weight to thigh level. With back and legs straight curl the dumbbells upward toward shoulders until forearms and biceps meet. Lower them until arms are completely extended and repeat. For increased development of the forearm, do the same exercise grasping the dumbbells in an overhand grip so palms are facing inward.

Safety: If using heavy weight, rocking back and forth during the exercise may cause injury to the lower back.

Key Points: - Keep the elbows back to maintain resistance on the biceps in the contracted position. Bringing the elbows forward will reduce the effect because the tension on the muscle will not be constant.

- Do not cheat by leaning forward when raising or backward when lowering the weight.

- Execute the exercise slowly.
- The exercise can be performed with a barbell.
- When using dumbbells, the weight can be lifted at the same time similar to a barbell curl or alternately.
- See figure 25

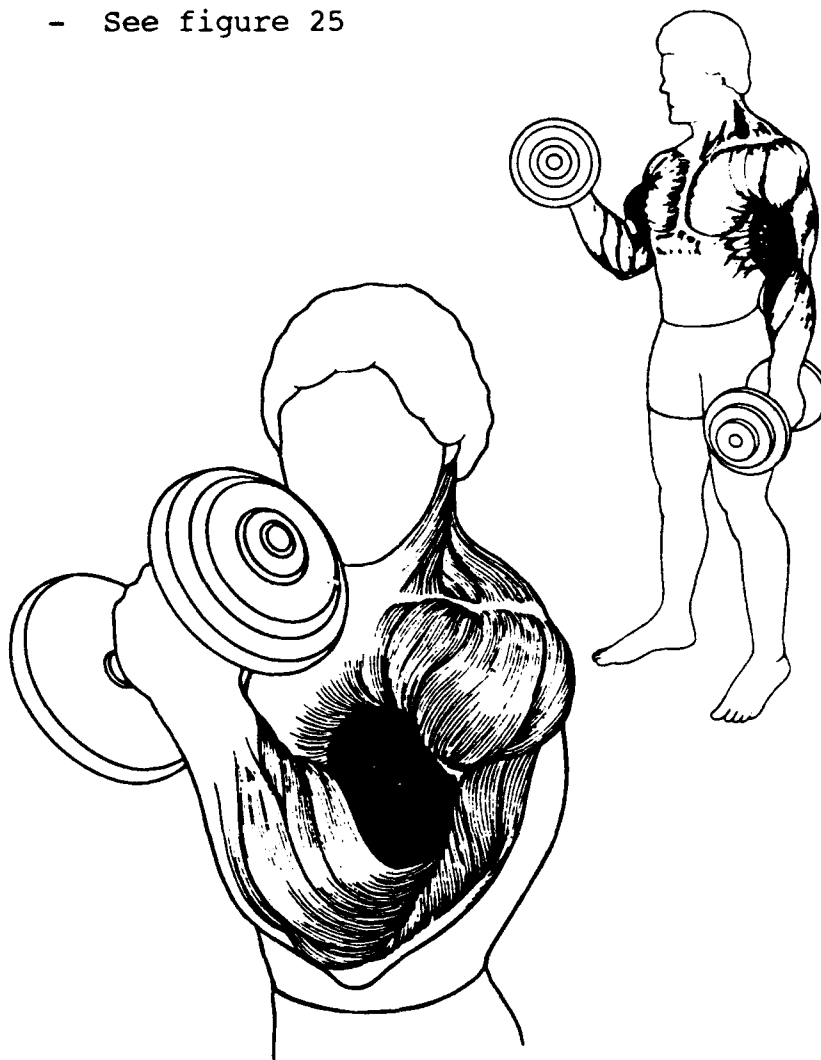


FIGURE 25

APPENDIX I: FOREARM EXERCISES

WRISTS CURL

Muscles Used: Primary-Forearms
Secondary-Biceps

Equipment: Barbell, Exercise Bench

Execution of the Exercise: Rest the forearms on a bench. With the hands and wrists hanging over the bench hold a barbell. Flex the wrist by raising the barbell from the fingertips to the palms of the hands.

Safety: Raise and lower the weight slowly to prevent injury to the forearms.

Key Points: - The forearms should remain in contact with the bench to provide a full range of motion during the exercise.

- See figure 26

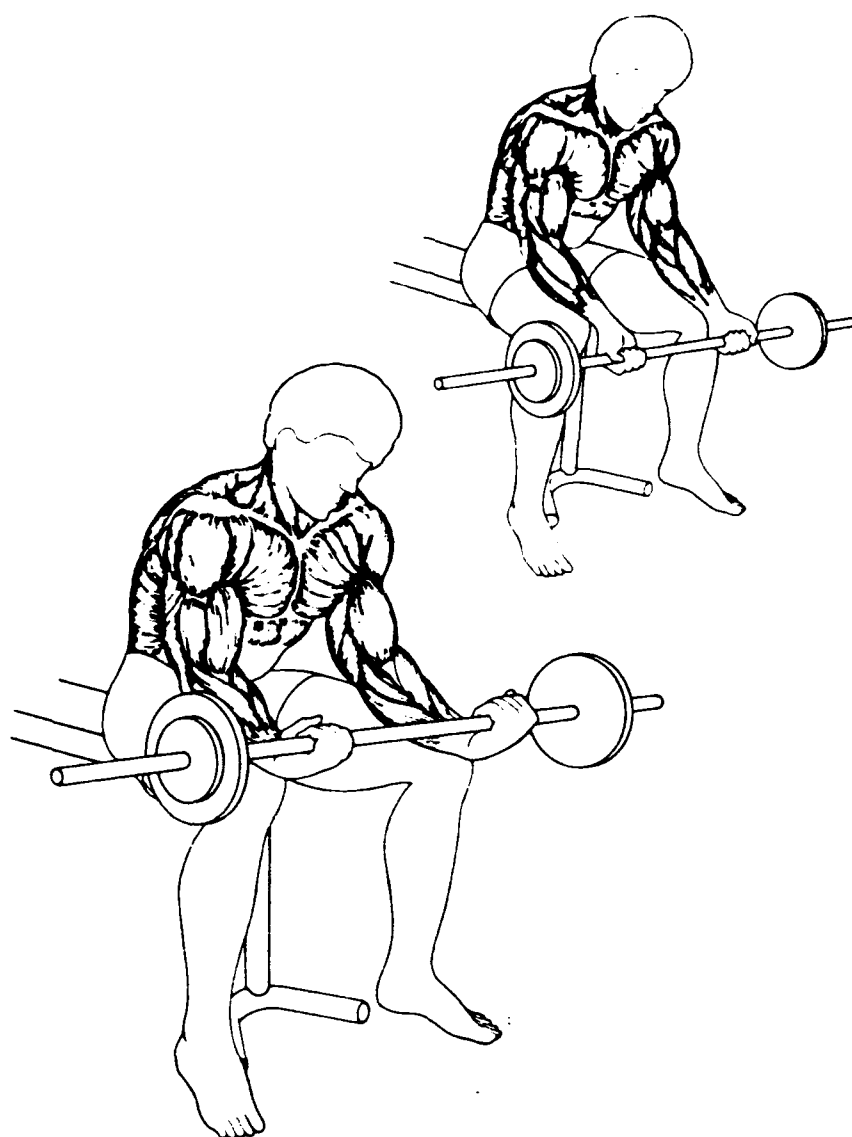


FIGURE 26

APPENDIX J: APPROVAL LETTER TO USE
EXERCISE DIAGRAMS

MEMORANDUM FOR RECORD

14 Jan 92

On this date, I received permission to use Bruce Algra Fitness Chart illustrations in my masters thesis from Mr. Mike Wilkins, Office Manager, 1-800-336-1322. (The only individual that out ranks Mr. Wilkins in the organization is the president). Mr. Wilkins also said that a follow-up letter was unnecessary.

Bradley W. May
Captain, U.S. Army

BIBLIOGRAPHY

Government Publications

- U.S. Army. Army Regulation 350-15, The Army Physical Fitness Program. Washington, DC, 1989.
- U.S. Army. Army Regulation 350-41, Army Forces Training. Washington, DC, 1986.
- U.S. Army. Field Manual 17-12-1, Tank Combat Tables, M1 with Change 1,2,and 3. Washington, DC, 1986.
- U.S. Army. Field Manual 21-20, Physical Fitness Training. Washington, DC, Dept of the Army, 1985.
- U.S. Army. Pamphlet 350-18, The Individual's Handbook on Physical Fitness. Washington, DC, 1983.
- U.S. Army. Pamphlet 350-15, The Commander's Handbook On Physical Fitness. Washington, DC, 1982.
- U.S. Army. Soldier Training Publication 17-19K1-SM Soldier's Manual M1/M1A1 Abrams Armor Crewman. Washington, DC, 1989.
- U.S. Army. Soldier Training Publication 21-1-SMCT, Soldier's Manual of Common Tasks Skill Level 1. Washington, DC, 1990.
- U.S. Army. Technical Manual 9-2350-255-10-3, Volumes 1 and 3, Operators Manual Troubleshooting and Maintenance for Tank, Combat, Full-Trackd 105-mm Gun, M1, General Abrams. Washington, DC, 1981.

Books

Columbo, Franco. Franco Columbo's Complete Book of Bodybuilding. Chicago, IL, Contemporary Books, Inc., 1982.

Darden, Ellington , Ph. D. The Nautilus Bodybuilding Book. Chicago, IL, Contemporary Books, Inc., 1982.

Fox, Edward L. Sports Physiology. PA: W.B. Saunders Company, 1979.

Getchell, Bud. Physical Fitness A Way of Life. John Wiley & Sons, Inc., 1983.

Goldomg, Lawrence A., Myers, Clayton R. and Sinning, Wayne E. The Y's Way to Physical Fitness. Chicago, IL, National Board of YMCA, 1982.

Hales, Dianne and Hales, Robert E. , M.D. The U.S. Army Total Fitness Program. New York, N.Y. Crown Publishers, Inc, 1985.

Kennedy, Robert. The New Hardcore Bodybuilding. New York, NY, Sterling Publishing Co., Inc. 1990.

Kennedy, Robert and Weis, Dennis B. Raw Muscle. Chicago, IL, Contemporary Books, 1989.

Kubistant, Tom. Mind Pump. Champaign, IL, Leisure Press, 1988.

Mathews, Donald K. and Fox, Edward L. The Physiological Basis of Physical Education and Athletics. 2nd ed. PA: W.B. Saunders Company, 1976.

McArdle, William, D.; Katch, Frank, I., and Katch, Victor L. Exercise Physiology: Energy, Nutrition, and Human Performance. 3rd ed. PA: Lea and Febiger, 1991.

Murray, Jim, and Karpovich, Peter, V., M.D. Weight Training in Athletics. NJ: Prentice-Hall Inc., 1956.

Nautilus Instruction Manual. DeLand, FL, Sports/Medical Industries, 1980.

Riley, Daniel P. Strength Training by the Experts. NY: Leisure Press, 1977.

Sharkey, Brian J. Fitness and Work Capacity. Washington, DC, U.S. Dept of Agriculture, 1977.

Sharkey, Brian J. Physiology of Fitness: Prescribing Exercise for Fitness, Weight Control, and Health. IL: Human Kinetics, 1979.

Articles

Anderson, Tim and Kearney, Jay, T. "Effects of Three Resistance Training Programs on Muscular Strength and Absolute and Relative Endurance." University of Kentucky, Research Quarterly for Exercise and Sport, Vol. 53, No. 1, 1982.

Atha, J. "Strengthening Muscle," Exercise and Sports Science Review, Vol. 9, 1981.

Berger, Richard. "Comparison of the Effect of Various Weight Training Loads on Strength." Texas Technological College, Lubbock, Texas, The Research Quarterly, Vol. 36, No. 2, 1964.

Berger, Richard. "Comparison between Resistance Load and Strength Improvement." Texas Technological College, Lubbock, Texas, The Research Quarterly, Vol. 33, No. 4, 1962.

- Berger, Richard. "Effects of Varied Weight Training Programs on Strength." University of Illinois, Urbana, Illinois, The Research Quarterly, Vol. 33, No. 2, 1961.
- Berger, Richard, A. "Optimum Repetitions for the Development of Strength." Lubbock, TX, Texas Technological College, The Research Quarterly, 1961.
- Bjornaras, B.S. "Flexibility and Strength Training Considerations for Young Athletes," NCSA Journal, Vol. 4, No. 6, 1982.
- Blanksy, B. and Gregor, J. "Anthropometric Strength and Physiological changes in Male and Female Swimmers with Progressive Resistance Training," Australian Journal of Sports Sciences, Vol. 1, No. 3-6, 1981.
- Clark, D.H. "Adaptations in Strength and Muscular Endurance Resulting from Exercise," Exercise and Sports Science Review, Vol. 1, 1973.
- Fiatarone, Maria A.; Marks, Elizabeth C.; Ryan, Nancy D.; Meredith, Carol N.; Lipsitz, Lewis A.; Evans, William. No.22, 1990. "High-Intensity Strength Training in Nonagenarians: Effects on Skeletal Muscle." The Journal of the American Medical Association, Vol. 263.
- Fleck, S.J. and Kraemer, W.J. "Designing Resistance Training Programs," Human Kinetics, 1987.
- Fleck, S.J. and Kraemer, W.J. "Resistance Training: Physiological Responses and Adaptations," The Physician and Sportsmedicine, Vol. 16, No. 3, 4, and 6, 1988.
- Hejna, W.F. "Prevention of Sports Injuries in High School Students through Strength Training," NCSA Journal, Vol. 4 (1), No. 28-31, 1982.

Jackson, Allen; Jackson, Timothy; Hnatek, Jan; West, Jane.
"Strength Development: Using Functional Isometrics in
an Isotonic Strength Training Program." North Texas
State University, Research Quarterly for Exercise and
Sport, Vol. 56, No. 3, 1985.

Kraemer, W. J. "Exercise Prescription in Weight Training:
A Needs Analysis." National Strength and Conditioning
Association Journal, Vol. 5, No. 1, 1985.

Lesmes, George R.; Costill, David L.; Coyle, Edward F.; and
Fink, William J. "Muscle Strength and Power Changes
during Maximal Isokinetic Training." Human Performance
Laboratory, Ball State University, Muncie, Indiana,
Medicine and Science in Sports, Vol. 10, No. 4, 1978.

McDonagh, M.J. and Davies, C.T. "Adaptive Response of
Mammalian Skeletal Muscle to Exercise with high Loads,"
European Journal of Applied Physiology, Vol. 52, 1984.

Pauletto, Bruno, M.S., C.S. C.S. "Sets and Repetitions."
NCSA Journal, Vol. 7, No. 6, 1985.

Unpublished Dissertations, Theses, and Papers

Campos, J.L. "Comparison of Strength Development of Adult
Males and Females undergoing Dynamic Weight Training."
University of Iowa, 1980.

Mello, R.P. "Assessment of Physical Activity Intensity
During Infantry Combat--Simulated Operations."
Natick, MA., Army Research Institution of
Environmental Medicine, 1986.

Myers, D.C., Gebhardt, D.L. and Fleishman, E.A.
"Physical Performance Standards for Army Jobs:
Criterion Task." Washington, DC., Advance Research
Resources Organization, 1980.

- Pleban, R.J. "Physical Fitness As A Moderator of Cognitive Work Capacity And Fatigue." Alexandria, VA, Army Research Institute For The Behavioral And Social Sciences, 1985.
- Ripple, G.R. "Ventilatory Requirements of M1 Tank Crew Members During Simulated Battlefield." Ft. Detrick, MD., Army Biomedical Research And Development Lab, 1989.
- Smutz, E.R. "An Assessment of Factors Influencing Gunnery Performance In An Army National Guard Armor Battalion." Army Research Institute for The Behavioral and Social Sciences, 1976.
- McWhorter, Thomas A. "A Strength Development Program for U.S. Army Field Artillery Cannon Soldiers," (Thesis, University of Georgia, Athens, GA, 1987)

INITIAL DISTRIBUTION LIST

1. Combined Arms Research Library
U.S. Army Command and General Staff College
Fort Leavenworth, Kansas 66027-6900
2. Commanding General, USAARMC
Directorate of Total Armor Force Readiness
ATTN: ATZK-TF
Fort Knox, Kentucky 40121
3. Defense Technical Information Center
Cameron Station
Alexandria, Virginia 22314
4. Lieutenant Colonel Lee F. Kichen
Combined Arms and Services Staff School
USACGSC
Fort Leavenworth, Kansas 66027-6900
5. Lieutenant Colonel David L. Wallinger
Tactics Instruction Division
USACGSC
Fort Leavenworth, Kansas 66027-6900
6. Colonel Jerry W. Warner
14 Rainbow Lane
Alexandria, Kentucky 41001